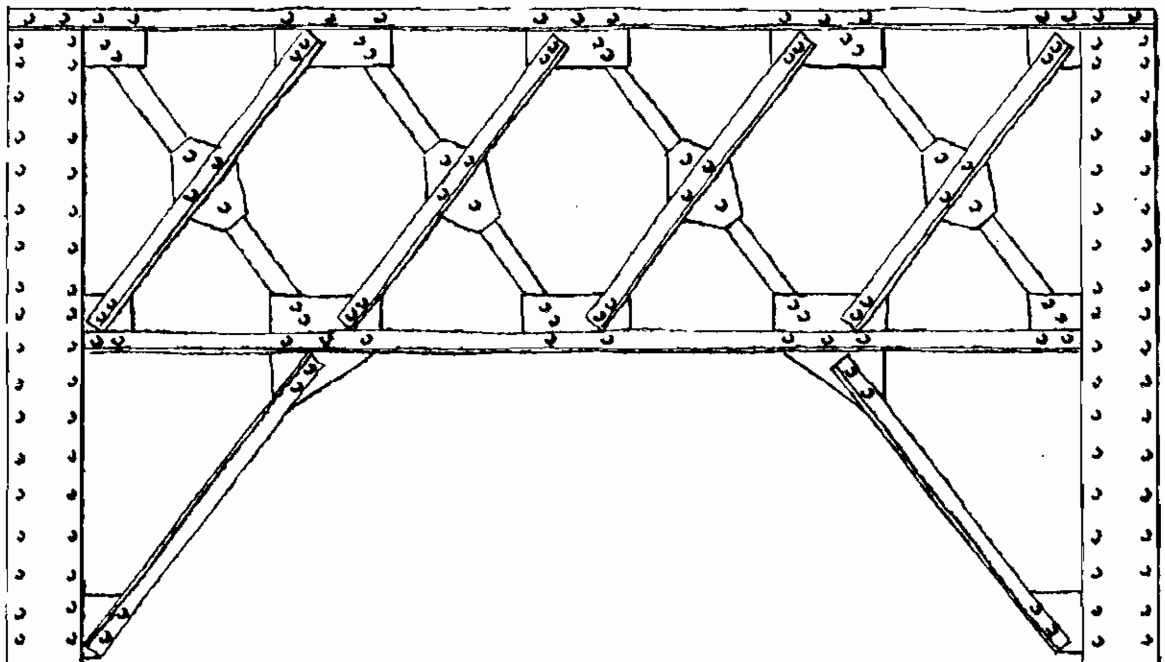
1897

A day in the estimating and designing room of a bridge contractor

Felix John Kersting



A THESIS

FOR THE

DEGREE OF C.E.

BY

F.J. KERSTING B.S. CLASS '97

MISSOURI SCHOOL OF MINES
ROLLA MO.

A DAY IN THE ESTIMATING AND DESIGNING ROOM OF A BRIDGE CONTRACTOR.

ENGINEERING DEPARTMENT, ... OFFICE. Inquiry No. 652 A
Order No.
ESTIMATE SHEET.
Sheet No. 2 of 3
Drawing No.

Estimate made from Our Plan Estimated by FJK 19 Checked by 19

FOR Butler Co Mo 80' High-Pratt-Riveted

No. of	Description		Unit Weight.	Total.		
2	15X½ Pls	15"	25.5	2.5	64	Fixed Shoes
4	6X4X½ Ls	15"	16.2	5.0	81	" "
4	15X½ Pls	15"	25.5	5.0	128	Roller "
4	6X4X½ Ls	15"	16.2	5.0	81	" "
10	2°	15"	10.7	12.5	134	Rollers
4	3x5/16	15"	3.2	5.0	16	" Nest
4	1°	2.0	2.7	8.0	22	" "
8	1°	1.0	2.7	8.0	22	Anchor Bolts
8	Nuts for same				5	

553
From Page ① 17292
17845
Rivets 4% 715
18560 # Total Weight

Joists

2-6"[	81.0	8	162.0	1290
5-6 I	81.0	12¼	405.0	4960

6250 #

Hand Rail

6	2x2x3/16" Ls	81	2.5	486.0	1215	Rail
432	1¾x¼	2.5	1.5	1080.0	1620	Lattice
28	6x3/16	6"	3.83	14.0	54	Conn Pls
24	3½x2½x¼"	6"	49	12.0	59	" Ls
1400	Rivets ½x1½		14#		176	

3144 ($\frac{3144}{80}$ = 39.4# per lft Bridge)

Lumber.

81 - 2½x12x12 Floor = 2430
10 - 4x6x16 Wheel Guard = 320
15 - 2x6x16 Spiking Pcs = 240
3090

ENGINEERING DEPARTMENT, ... OFFICE. Inquiry No. 652 A
Order No.
Sheet No. 5 of 3
Drawing No.

ESTIMATE SHEET.

Estimate made from Our Plan Estimated by FJK 19 Checked by 19

FOR Butler Co Mo. 80' Rivets

No. of	Description	Unit Weight.	Total.

To Get Average Price Material for Trusses

ES LS Pls	17662	@ 1.50	=	265.00
Rods & Pins	178	@ 2.25	=	4.00
Rivets	715	@ 1.80	=	12.90
Nuts	5	@ 5.50	=	28
	18560			282.18

$\frac{282.18}{18560} = 1.52$

Metal	1.52	For Trusses	Metal =	1.50	For Joists	Metal	1.50
Shop	.85		Shop =	.25		Shop	1.50
Paint	.05		Paint	included in shop		Paint	included in shop
Frt. Pitts St L	.20		Frt	20		Frt	20
" St L to site	.27		Frt	27		"	27
	2.89			2.22			3.47

(For Hand Rail: last two columns)

Metal 18560#	@ 2.89	=	536.00
Joists 6250#	@ 2.22	=	139.00
Hand Rail 3144#	@ 3.47	=	109.00
Lumber 3.1 BM	@ 27.50	=	85.00
Haul 9 tons	@ 1.00	=	9.00
Erection 9 tons	@ 20.00	=	180.00
Cost		=	1058.00
Profit			212.00
			$1270.00

ENGINEERING DEPARTMENT, ... OFFICE.

Inquiry No. 652 T
Order No.
Sheet No. 1 of 3
Drawing No.

ESTIMATE SHEET.

Estimate made from Our Plan Estimated by FJK 19 Checked by 19

FOR Butler Co Mo 80' Pratt-High-Riveted

No. of	Description	Unit Weight.		Total Length			
4	5 [	48	6.5	192.0	1250	X	Top Chord
2	10×1/4 Pls	48	8.5	96.0	815	X	" "
16	4×5/16 "	2.0	4.2	32.0	134		Splices
8	10×1/4 Pl	2.0	8.5	16.0	136		"
192	1 3/4×1/4 Pls	9"	1.5	144.0	216		Lattice under side
8	5 [	22.6	6.5	181.0	1180	X	End Post
4	10×1/4 Pl	22.6	8.5	90.0	760	X	" "
8	27×5/16 "	3.0	28.7	24.0	690		at Shoes
180	1 3/4×1/4 "	9"	1.5	135.0	203		Lattice under side
8	2×2×1/4	80.0	3.2	640.0	2050	X	Lower Chord
32	6×1/4	6"	5.1	16.0	82		Battens
8	30×1/4	2.5	25.5	20.0	510		Gussets
8	36×1/4	3.0	30.6	24.0	735		"
32	3×2×1/4	16.0	4.1	576.0	2120	X	Verticals
40	6×1/4	6"	5.1	20.0	102		Battens
8	8×1/4	1.5	15.3	12.0	184		Gussets
8	22×1/4	3.0	18.7	24.0	450		"
16	3×2×1/4	21.5	4.1	344.0	1410	X	Diagonals
4	8×1/4	1.0	6.8	4.0	27		Gusset
16	2 1/2×2 1/2×1/4	19.0	4.1	304.0	1246	X	Laterals
8	6×1/4	1.0	5.1	8.0	41		Conn Pls
12	6×1/4	1.5	5.0	18.0	92		" "
8	6×1/4	1.0	5.1	8.0	41		Gussets
4	3 1/2×2 1/2×1/4	12.0	4.9	48.0	236	X	Top Strut
4	3×3×1/4	3.0	4.9	12.0	59	X	Knees
8	6×1/4	9"	5.1	6.0	31		Conn Pls
8	3 1/2×2 1/2×1/4	12.0	4.9	96.0	470	X	Portals
16	"	3.5	4.9	54.0	264	X	"
8	"	6.0	4.9	48.0	235	X	"
32	6×1/4	9"	5.1	24.0	122		Conn Pls
4	12 I	13.0	31.5	42.0	1320	X	Floor Beams
16	3×3×7/16	10"	6.1	13.5	81		" " Conn
					17292		

The following designs are supposed to be made for the contracting department of a bridge shop or contracting firm, with a view of being submitted in competition.

The Competitors in the field of Structural steel in this Western Territory are as numerous as in the East, though most of the shops are located there. There are small shops in St L Chicago, Minn. Milwaukee and points in Ind and Ohio.

The American Bridge Co fabricates 60% of the Structural Steel now used in this Country. They have contracting offices in nearly every large city in the U. S. Each of these offices has a manager, an office engineer, two or three Contracting agents Clerks etc. When a contract is taken, the requisite blanks are filled out and sent with the Contract drawings (which are usually the Architects' drawings in case of a building and the office engineers' show plan in case of a bridge) to the Western Headquarters at Chicago. From that point it is placed in one of the Am Br Co's Western shops usually, which are at St Louis, Minneapolis, Milwaukee and Lafayette Ind.

The independent shops usually have a Chief Engineer, an Asst Engineer in charge of from two to five estimators and a chief draftsman in charge of the detailing force which may number from six to fifty men according to the size of the shop and need of work.

Other Competitors besides the Am Br Co are the independent Bridge Co's who have shops, Bridge Contractors who have no shops of their own, ~~[illegible]~~ do their own erecting and sublet the fabrication of the structural steel which they have contracted to furnish, and those who sublet steel and erection.

Wanted: The Cost and Design for a Steel Support for a 10000 gallon Tank, head to be about 60 ft.

Assume tank to be 12' dia and 12 high; the Contents are $\frac{\pi (12)^2}{4} \times 12 = 1357.2$ Cu ft.

1357.2 Cu ft $\times 7.5 = 10000$ gals.

The tops of the posts will then form a square of 12 ft side; these tops will be connected by girders upon which will set 2×12 joists (placed diagonally in order to distribute the load over 4 girders instead of 2) and on the joists will be placed a 2½ floor.

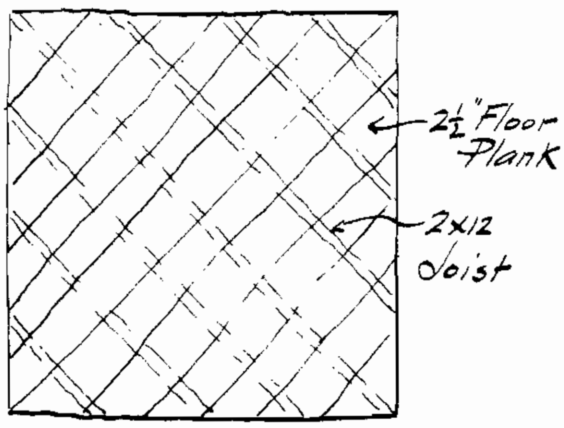


Fig 1.

(Sketches like Fig 1 will clearly define the designers ideas and should be kept and pinned to his estimate sheets; in case the contract is secured these sketches will be an aid to the detailer and enable him to keep the weight of the structure inside the designer's estimate)

The legs are to be about 60 ft high - divide this into 4 panels of 14 each, which will be about the correct unsupported length for posts as light as these will be. The Concrete bases are usually allowed to project 1' above ground and the bottom strut must be at least 2' above the top of concrete base in order to allow clearance for shoes.

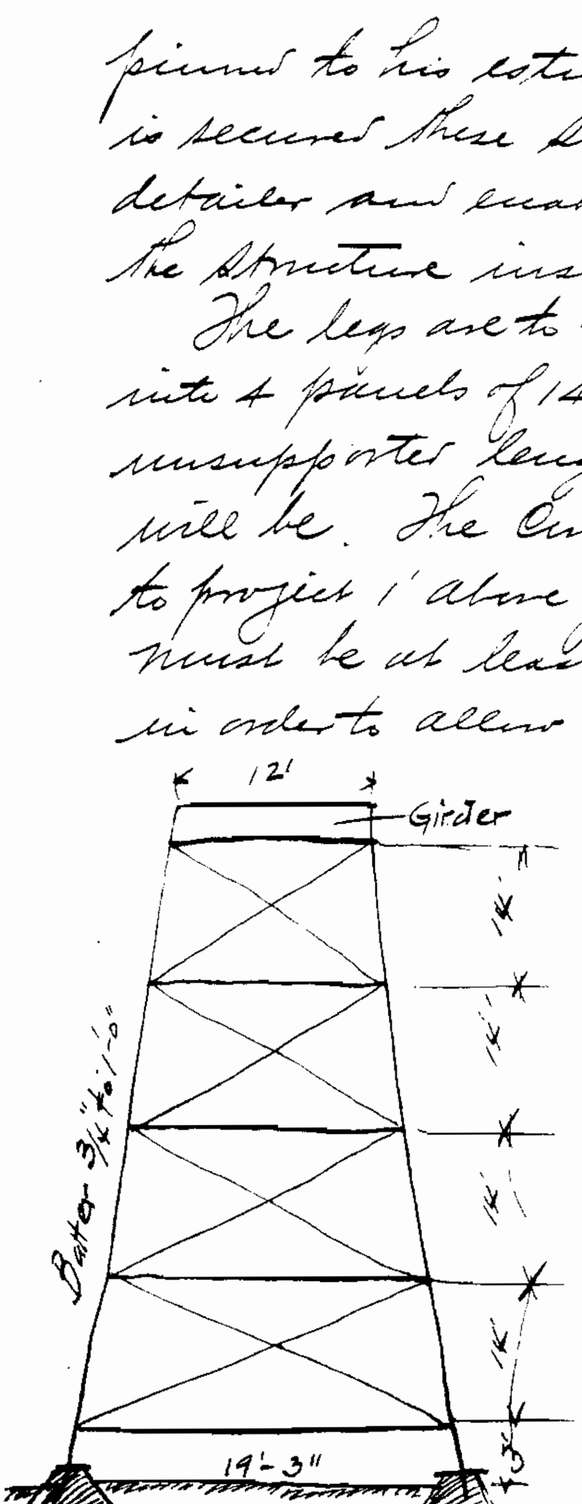


Fig 2.

Draw another free hand sketch in order to get an idea of the looks of the structure.

Let the posts have a batter of 3/4" to 1'-0" then the distance C. to C. Concrete piers will be

$$12' + 2(4 \times 14 + 2)\frac{3}{4} = 12' + 7'\text{-}3'' = 19'\text{-}3''$$

To get the Direct Compression in Posts: The water will weigh 1357.2 X 62.5 = 86000#. The Board Measure for Tank etc will be about:

Floor	12 pcs	$2\frac{1}{2}$" 12" X 12' =	360
Jsts	7 "	2 X 12 X 12 =	170
Tank	120 "	$2\frac{1}{2}$ X 4 X 13 =	1300
Top	12 "	$2\frac{1}{2}$ X 12 X 12 =	360
Bot	12 "	$2\frac{1}{2}$ X 12 X 12 =	360

Wt. of 1 ft B.M.

2550 X 5 = 12700

Add for Hoops etc 700 = 13400

Guess the weight of the legs, bracing etc at 10600. If this DL is found to be radically off when the structure is designed, the whole thing should be redesigned for the corrected DL.

We have Water 86000#
Tank etc 13400#
Substructure 10600
110000 total

Wt on each leg = $\frac{110000}{4}$ = 27250# direct Stress.

To Get Stress due to Wind; first get the wind forces acting - take wind at 30# per sq ft of exposed surface of tank, it being a cylindrical surface and 50# per □' on the rest of the Structure.

The tank (allowing a little extra) is about 15' high and 13' wide, and girder below tank being one foot deep the wind force is

16 X 13 X 30 = 6240#

This force can act only on one side at one time and will be taken by two legs as will be seen from Fig 3. Causing tension on one side and compression on the other. The tension must be neglected and the compression must be added to the direct compression. The force at the top is then $\frac{6240}{2}$ = 3120#. The other wind forces will act at the joints. Assume the legs to be 1 ft wide and the Struts 8" wide. We have for each force then (see Fig 4)

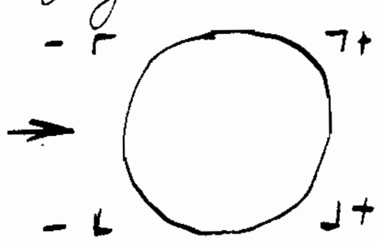


Fig 3

14 X 1 X 50 = 700
2 X $\frac{2}{3}$ X 11 X 50 = 750
$\frac{2}{3}$ X 10 X 50 = 340
1790

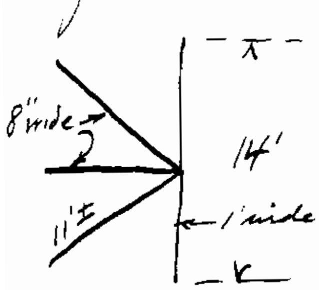


Fig 4

This force will act on two sides as shown in Fig 5 and will therefore be

1790 X 2 = 3580#

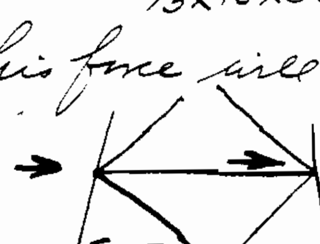


Fig 5

In addition to the 3120# at top we will have (Fig 6)

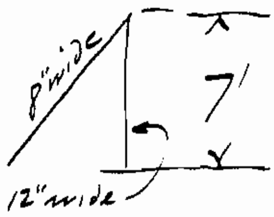


Fig 6

$7 \times 50 \times 1 = 350$

$11 \times 50 \times 2/3 = \underline{400}$

$750 \times 2 = 1500^{\#}$

or a total of $3120 + 1500 = 4620^{\#}$

Draw another sketch to scale, showing the wind forces acting. The stress due to wind in the members is found by moments. ~~Extend~~ Extend the legs to an intersection O and draw the lever arms of diagonals CB etc.

Only one diagonal in a panel can act at one time, as CB AD being idle for the wind forces as shown.

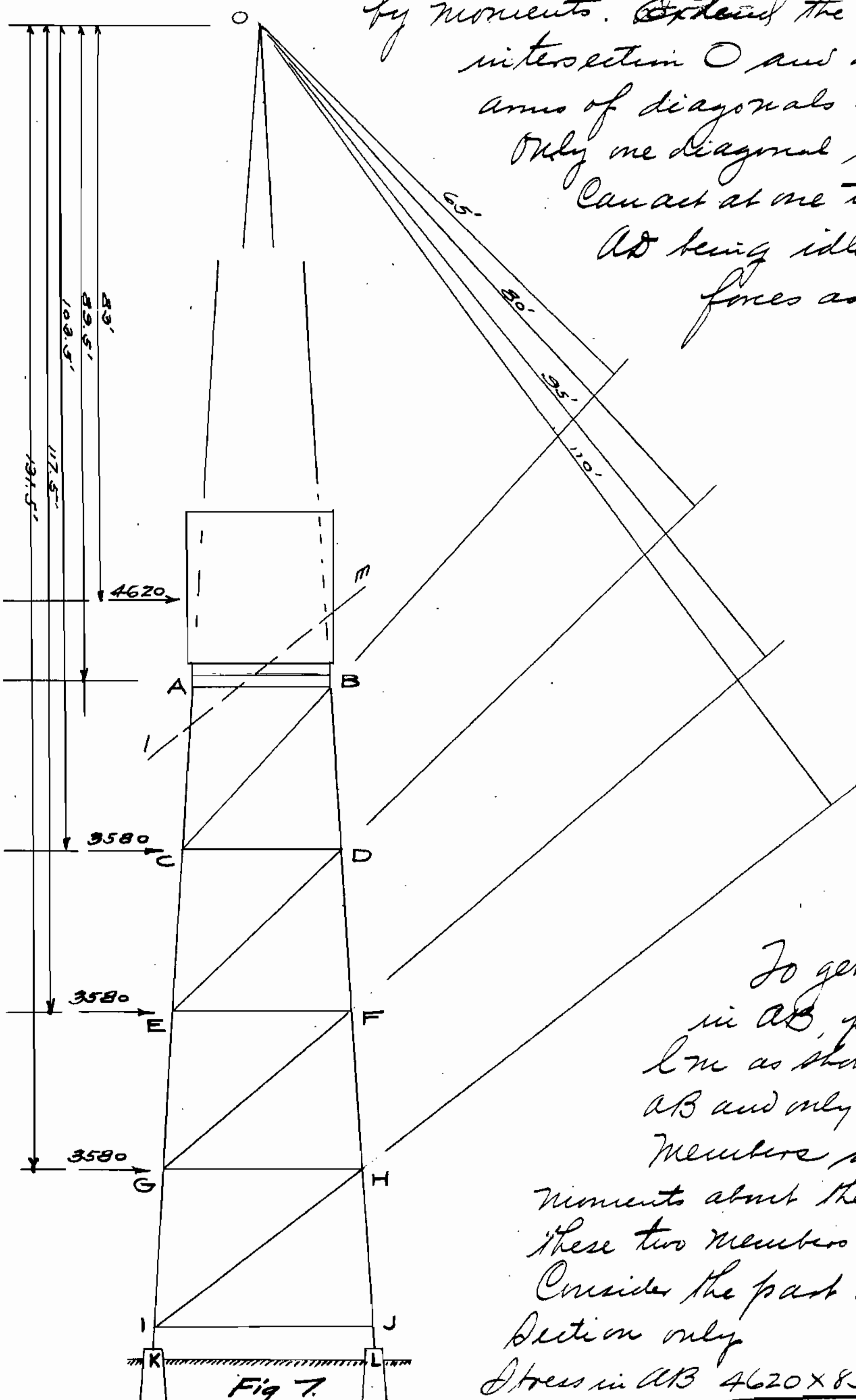


Fig 7.

To get wind stress in AB, pass a section lm as shown, cutting AB and only 2 additional members, and take moments about the pt where these two members meet. Consider the part above the section only.

Stress in AB $\dfrac{4620 \times 83}{89.5} = 4300^{\#}$

Stress in CD $\dfrac{4620 \times 83 + 3580 \times 103.5}{103.5} = 7300^{\#}$

Stress in EF = $\frac{4620\times 83 + 3580\times(103.5+117.5)}{117.5}$ = 10000#

Stress in GH = $\frac{4620\times 83 + 3580(103.5+117.5+131.5)}{131.5}$ = 12500#

Stress in IJ = $\frac{4620\times 83 + 3580(103.5+117.5+131.5+145.5)}{145.5}$ = 14900#

IJ is usually designed for a stress of 25% of the DL on the shoes or $\frac{110000}{4}$ = 27500#. This takes care of the temperature stress, the shoes being bolted into the foundations. These are all compressive stresses.

For stress in BD take moments at C, for that in DF, at E etc.

$BD = \frac{4620\times 22}{14} = 7300$

$DF = \frac{4620\times 36 + 3580\times 14}{15.5} = 14000$

$FH = \frac{4620\times 50 + 3580(28+14)}{17.5} = 21800$

$HJ = \frac{4620\times 64 + 3580(42+28+14)}{19.0} = 31400$

We will take these stresses as compr. and add them to our direct compr. since they are tension or compression

For stress in diagonals take moments at O

$CB = \frac{4620\times 83}{65} = 5900$#

$ED = \frac{4620\times 83 + 3580\times 103.5}{80} = 9500$

$GF = \frac{4620\times 83 + 3580(103.5+117.5)}{95} = 12400$

$IH = \frac{4620\times 83 + 3580(103.5+117.5+131.5)}{110} = 15000$

These are tensile stresses.

In order to keep down shop cost we will use one sized rivet throughout and this will be 3/4" dia. The smallest angle which will take a 3/4" rivet has a 2½" leg and as almost all specifications now call for 1/4" to be the least thickness of metal allowed a 2½×2½×1/4 angle will be the least member used in this structure which will have riveted bracing.

Design

For Diag IH we require $\frac{15000}{17000}$ = .88□" net section

17000# being allowable tension stress per □" for laterals and bracing.

A 2½×2½×1/4 L = 1.19□" (C.P.C. Page 38)
Less 1 Rivet Hole (7/8×1/4) = .22
.97□" net.

This is more than enough and as the stresses in all other diagonals are less than in IH, a 2½×2½×1/4 L will be used for all diagonals.

more that in subtracting rivet holes the diam of hole is always taken $\frac{1}{8}$ larger than the Rivet, whereas it is really punched $\frac{1}{16}$" larger than the Rivet.

To design Compression Members IJ etc we will use 120 as our greatest $\frac{l}{r}$

The length of IJ = 19 × 12 = 228" The $\frac{l}{r}$ for IJ must then be $\frac{228}{120}$ = 1.9 or greater

By referring to Page 145 C.P.C. we see that we cannot get 2 angles back to back whose r_0 and r_2 = 1.9 (angles marked by a star should not be used as they are specials and are not rolled by the mills until a large order of them accumulate which will warrant them changing their rolls, therefore the delivery of these angles may be delayed a year or more).

Suppose instead, we use two Ls with the short legs b to b. and drop a light L from the intersection of IH and GJ to the strut IJ. The length of IJ will then be 228" for r_2 and 114" for r_0 and r_2 will have to be $\frac{228}{120}$ = 1.9 and r_0 $\frac{114}{120}$ = .95 On Page 146 CPC we see that the r_0 for 2-5×3×$\frac{5}{16}$" Ls so placed is .85 and the r_2 = 2.51

As 120 is low for the $\frac{l}{r}$ in a member stressed by wind and as some inches can be subtracted from the length of IJ. on a/c of the gusset plates at the end, these Ls will be used if they have enough section to take the stress.

The formula mostly used for Compression members is $p = \dfrac{17000}{1 + \dfrac{l^2}{11000\, r^2}}$ for Medium Steel

for $\frac{l}{r}$ = 120 this gives 7360#

$$\frac{\text{Stress in IJ}}{\text{Allowable stress}} = \frac{27500}{7360} = 3.74\ \square\text{" Reqd.}$$

2-5×3×$\frac{5}{16}$ Ls = 4.80 C.P.C. Page 146

These Ls will be used

The small strut which was dropped to IJ receives no stress which can be figured and is simply designed for its $\frac{l}{r}$. Its length will be 7 × 12 = 84" and its r = .77 C.P.C. Page 118

$\frac{84}{.77}$ = 109 therefore this small strut will be a $2\frac{1}{2}$×$2\frac{1}{2}$×$\frac{1}{4}$" L

To design GH. Its length is 17'-6" = 210"

$\frac{210}{120} = 1.75$ for r_2 or $.875$ for r_0

See CPC Page 146, 2-4×3×$\frac{5}{16}$" $\angle^s$ $r_0 = .89$ & $r_2 = 1.97$

Stress in GH = $\frac{12500}{8410} = 1.48$ Requd

2-4×3×$\frac{5}{16}$ $\angle^s$ = 4.18

Here the $\frac{l}{r}$ was $\frac{210}{1.97} = 106$ for which the allowable stress is 8410. It will be seen that these 4×3 $\angle^s$ give a section much too large for the stress but they must be used on account of the $\frac{l}{r}$

EF is 15.5'×12 = 186" long

$\frac{186}{120} = 1.55$ is r_2 requd and .775 is r_0 Requd.

2-3½×2½×¼" $\angle^s$ fill these requirements.

CD is 13.5×12 = 162" long

$\frac{162}{120} = 1.35$ r_2 Requd and .675 r_0 Requd

2-3×2½×¼" $\angle^s$ fill the requirements. It is not necessary to try for the stress as we saw in GH that the $\frac{l}{r}$ ran high.

As it is best for shop purposes to have the least no of kinds of sections in a structure we will use 2-3½×2½×¼ $\angle^s$ for CD as we did for EF as the saving is so very small.

To design BD. In a small structure like this one no piece should leave the shop which can not be shipped on one car, as freight rates are an important item in cost. This governs the splices to a great extent. The longest piece which can be shipped on one car is 33'. 30 ft is usually the length adapted.

We will use 2 $\angle^s$ b to b for BD as this section is more economical than an I Beam whose r is small one way. The length is 14' or 168" and the stress 27500 + 7300 = 34800

Try 2 $\angle^s$ 5×3×$\frac{5}{16}$ b to b Page 145 C.P.C. r = 1.26

$\frac{168}{126} = 136$ which is too large

try 2 $\angle^s$ 5×3½×$\frac{5}{16}$ = $\frac{168}{150} = 112$

The allowable stress is 7940 and $\frac{34800}{7940} = 4.38$ □" Requd.

2-5×3½×$\frac{5}{16}$" $\angle^s$ = 5.12 (CPC page 145)

therefore these $\angle^s$ will be used

DF is also 168" long and the stress is 27500 + 14000 = 41500 Using the same Ls as in BD we have $\frac{41500}{7940} = 5.23$ □" Requd. This is near enough and will be used.

FH is 168" long and its Stress is 27500 + 21800 = 49300 Try 2 Ls 5 X 3½ X 3/8. The $r_0 + r_2$ is practically that of the 5/16" Ls therefore the allowable would be the same

$\frac{49300}{7940} = 6.22$ □" Requd. CPC Page 40 gives 2 Ls 5 X 3½ X 3/8 as 6.10 which is close enough

HJ is 168" long and its Stress is 27500 + 31400 = 58900

$\frac{58900}{7940} = 7.43$ □" Requd. This takes 2 Ls 5 X 3½ X ½"

To design Girder AB. The load on the girder will be

Wt of Water 86000#
Tank Etc 13400#
100000

$\frac{100000}{4} = 25000$#

length is 12'

Max Moment is $\frac{25000 \times 12 \times 12}{8} = 450000$ inch #

$\frac{450000}{17000} = 26.5$ Section Modulus Requd

(CPC Page 98) a 10" I 25# being too light we will not use a 10 I 30# but a 12" I 31½# as only those sections in bold type should be used when they cause no great waste

To investigate Anchorage

Take Moments about L

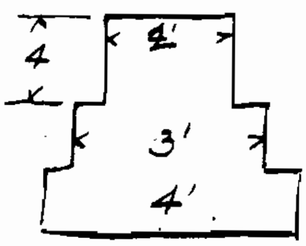
$$\left.\begin{array}{l} 4620 \times 66 = 304000 \\ 3580 \times 44 = 156000 \\ 3580 \times 30 = 107000 \\ 3580 \times 16 = 57000 \end{array}\right\} = 624000 \qquad \begin{array}{r} 624000 \\ \underline{527000} \\ 97000 \end{array}$$

$\underset{(\frac{1}{2}\text{ Total Wt})}{55000} \times \underset{(\frac{1}{2}\text{ Base})}{9.6} = 527000$ $\qquad \frac{97000}{\underset{(\text{Base})}{19.25}} = 5000$ uplift

The usual Anchor Bolts will easily take care of this as they are 2 Rods 3/4" ○ which have an area of .88 (CPC Page 261) and 17000 x .88 = 15000#

The Size of Bed Plate: Pressure at foot of Post = Stress in HJ = 58900 Allow 200# per □" for Concrete

$\frac{58900}{200} = 295$ □" Requd = 18" Square To Provide for the uplift we must have at least 5000# of Concrete in each base, at 150# per cu ft this requires 33 cu ft.



The top will be 2' □ as our bed plate is 1.5' □

2 x 2 = 4 □' = area on top, 4 x 4 = 16 cu ft

3 x 3 = 9 □' 9 x 2 = 18 cu

4 x 4 = 16 □' 16 x 2 = 32 cu = 66 Cu ft

which allows a factor of safety of 2 besides the wt of the earth resting on the Concrete.

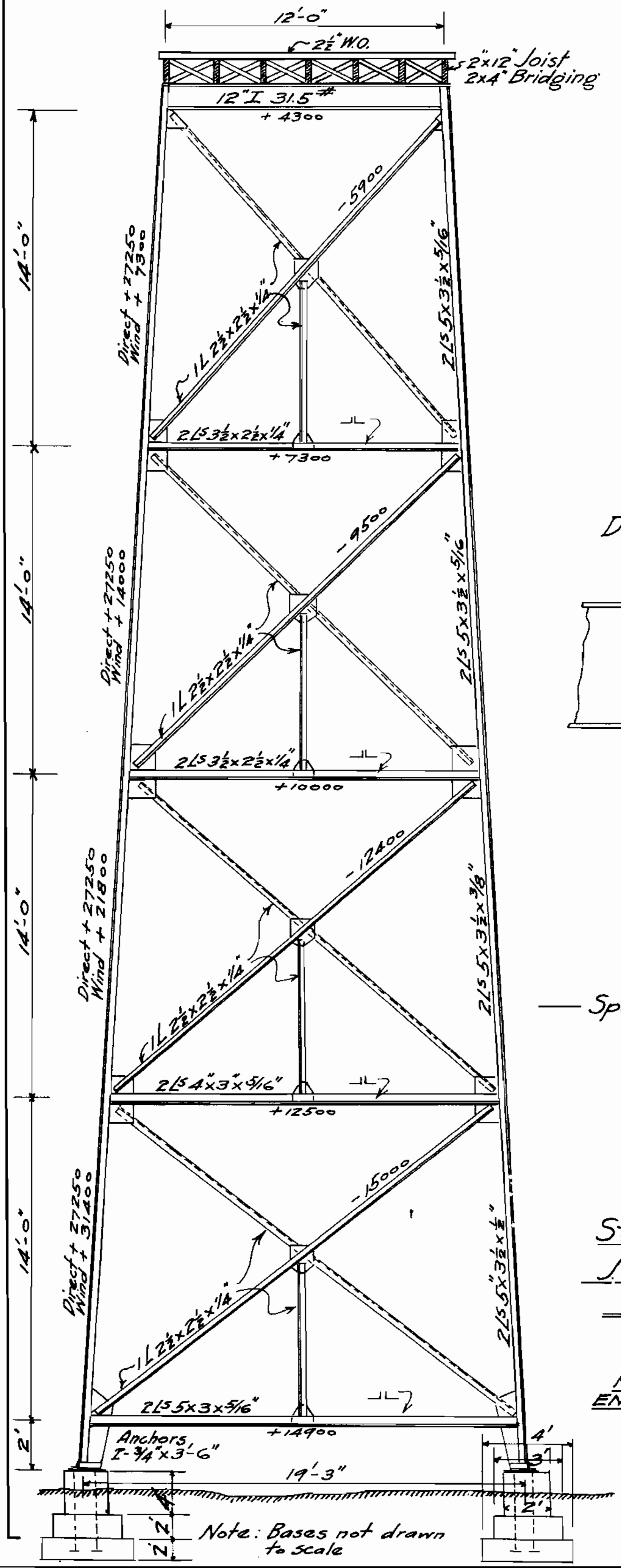
Foundation: The pressure on the Bed Plate is 58900# and the wt of the Concrete base is 10000# = total of 68900# or 35 tons say. The base of the Concrete is 16 sq ft. or $\frac{35}{16}$ = 2.18 tons pressure in the soil per □'. The nature of the soil must be know; the base may have to be extended.

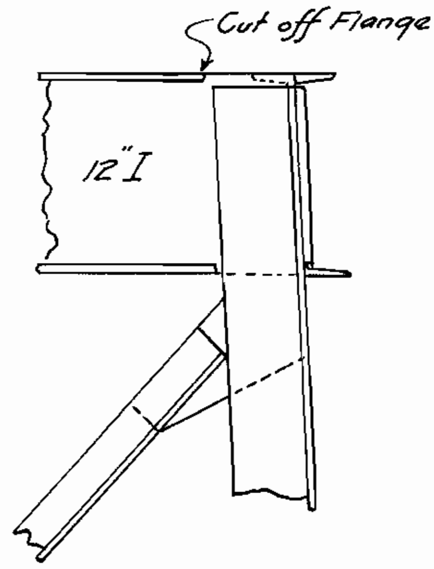
All data to make a cost estimate is now at hand. The estimator must be able to guess at the details and come close. The estimate can easily be followed on the succeeding two pages, the page numbers in Carnegie' Hand Book being given for weights. It is not necessary to give these in making an estimate.

By adding the wts of the main members, we have 12580# and details 2170# or 17.3 %

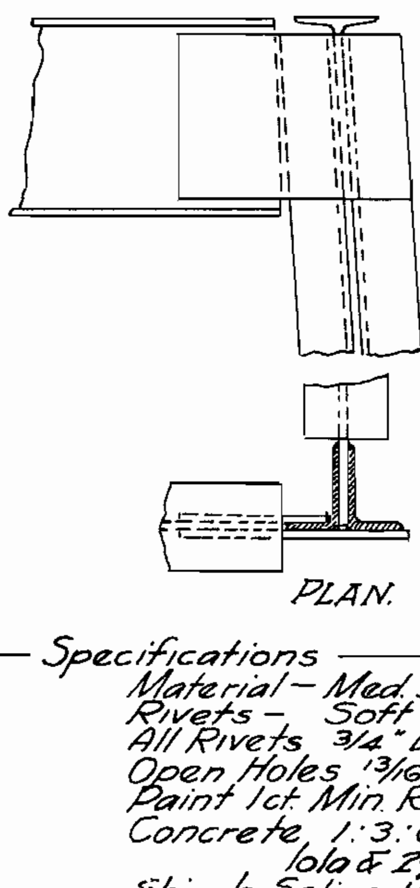
The nearest place to Salina Kas where this tower may be fabricated is St Louis. At present the price of Beams (under 15") Channels Angles (under 6") Plates etc is quoted at 1.40 St L which is 1.60 Pittsburg. If it is desired to have this tower in 5 or 6 weeks delivery, $5.00 a ton must be added to the price for "out of stock;" else the delivery would be anywhere from 6 to 12 months. The Cost of the Shop work, detail drawings, & one ct of paint at Shop for this Class of work is about 90 ¢. About 1/4 of the Shop Cost is added for general, Contracting and administrative expense. The Profit added usually varies from 5% when Competition is Close, 15% (the usual) to Sometimes 40%.

The estimator now gives his sketches to the draftsman and after blue prints are made turns all over to the Asst Engineer.





DETAILS AT TOP



PLAN.

— Specifications —
Material – Med. Steel O.H.
Rivets – Soft Steel
All Rivets ¾" Dia.
Open Holes 13/16" Dia.
Paint 1ct. Min. Red at Shop.
Concrete, 1:3:6
Iola & 2½" Ring
Ship to Salina Kas.
via C.R.I.&P. R.R.

STEEL TANK SUPPORT
FOR
J.H. ANDREWS & SON
SALINA KAS.
Scale 3/16"=1'-0"

KANSAS CITY BRIDGE Co.
ENGINEERS & CONTRACTORS.
KANSAS CITY MO.

5-3-05 F.K.

Form G 2.

KANSAS CITY BRIDGE COMPANY.

ENGINEERING DEPARTMENT.

Inquiry No. 2124
Contract No.
Sheet No. 1 of 2
Drawing No.

ESTIMATE SHEET.

Estimate made from Own Plan Estimated by FJK 5/3 1905 Checked by ——— 19

FOR J. Andrews Son
Salina Kas

No. of	DESCRIPTION		UNIT WEIGHT	TOTAL Length	Wt.	See Page in C.P.C. for wt.	
1	Steel Tank Support of						
8	5×3½×½ Ls	14.0	13.6	112.0	1520	39	Legs
8	5×3½×3/8 Ls	14.0	10.4	112.0	1170	40	
8	5×3½×5/16 Ls	29.0	8.7	232.0	2020	40	
8	5×3×5/16 Ls	18.5	8.2	148.0	1210	40	Struts
8	4×3×5/16 Ls	16.5	7.2	132.0	950	40	
8	3½×2½×¼ Ls	15.0	4.9	120.0	590	41	
8	"	13.5	4.9	108.0	540	41	
4	12" I	12.0	31.5	48.0	1510	4	
16	2½×2½×¼ Ls	6.7	4.1	102.0	440	38	
8	"	22.0	4.1	176.0	720	38	Bracing
8	"	20.5	4.1	164.0	670	38	
8	"	19¼	4.1	154.0	640	38	
8	"	18.5	4.1	148.0	600	38	
8	3/4"°	3.5	1.5	28.0	40	261	Anchors
8	Nuts for 3/4"°		1/4	"	10	204	
8	6×½ Pls	.5	10.2	4.0	40	253	
4	18×½ "	1.5	30.6	6.0	180	257	Shoe Details
4	18×5/16 "	1.5	19.1	6.0	120	257	
4	6×6×½ Ls	1.5	19.6	6.0	120	37	
8	" "	1.0	19.6	8.0	160	37	
4	14×5/16 Pl	3.5	14.9	14.0	210	257	
24	15×¼ "	2.0	12.8	48.0	620	257	Gussets
32	6×¼ "	3/4	5.1	24.0	120	253	
2	12×¼ "	1.0	10.2	2.0	20	253	
4	10×3/8 "	1¼	12.8	5.0	60	255	at top
4	10×3/8 "	3/4	12.8	3.0	40	255	
	3% Rivets				430		
					14750#		

Lumber
12 pcs 2½×12×14 = 420
7 " 2×12×14 = 196 = .62 Bm.

Concrete
4 - 2×2×4 = 64
4 - 3×3×2 = 72
4 - 4×4×2 = 128 = 264 cu ft = 10 cu yds

Excavation
4-5×5×7 = 700 cu ft = 26 cu yds.

Form G 2.

KANSAS CITY BRIDGE COMPANY.

ENGINEERING DEPARTMENT.

Inquiry No. 2124
Contract No. 8
Sheet No. 8 of 2
Drawing No.

ESTIMATE SHEET.

Estimate made from Our Plans Estimated by FJK 5/3 1905 Checked by —— 19

FOR J Andrews Son
Salina Kas

No. of	DESCRIPTION	UNIT WEIGHT	TOTAL

Metal

F.O.B. Pittsburg	1.60
Frt to StL	.20
Taken from Stock	.25
Frt StL to Salina	.60
Shop work	.90
O/H Expense	.22
	3.77 F.O.B. Salina Kas

Metal 14750# @ 3.77	=	555.00
Excavation 26 cy @ 30¢	=	8.00
Concrete 10 cy @ 7.00	=	70.00
Lumber .62 Mft @ 30.00	=	20.00
Haul to site 8 tons - 3 mi @ 1.00	=	24.00
Erection - (Steel) 7.5 tons @ 8.00	=	60.00
" (Lumber) .6 Mft @ 10.00	=	6.00
	Cost	743.00
	Profit	117.00
		860.00 Bid

Required - An 80 ft through Truss Span
12 ft Roadway - 100# Bridge (Chance for a Riveter)

In order to design and estimate intelligently the estimator must be familiar with Conditions which usually attend "Bridge Lettings". In 99 cases out of a 100, the lightest & "skimmiest" thing which will stand up must be designed. In this case we will assume there is a chance to build a fair bridge.

By a 100# Bridge is meant one designed for a L.L of 100# per sq ft of Bridge; in this case, having a 12' Roadway, it means 1200# per lin ft of Br.

Most highway bridges are built by Counties. Each County has a Bridge Commission, usually consisting of 3 members and the Co Surveyor.

When it is decided to build a Bridge, the fact - according to law - must be advertised in the local paper. The Bridge Co's subscribe for many of these papers, in this way the technical journals also hear the "news" and reprint it. But the Bridge Co's are usually apprised of the fact by postal Cards left with the Co Clerk on a previous "letting". By Bridge Co's are meant not only those having structural shops but also bridge Contractors and "Bridge Scalpers"

On the day of the "letting" usually (in Ill Mo Kas etc) from 5 to 40 agents attend according to the size of the contract to be let.

If these think the County Board will "stand for it" and if they are all friendly, these agents will each make out their cost estimate, if they must "bid on their own plans"; then appoint a committee of two or three to make a common cost estimate and grade the rest of the agents according to their estimates. Thus if the Committee A, B & C make a cost estimate of $5800 and A has "asked for the Concession" - if all the agents present are friendly to A he will take the contract at the figure he thinks he can get from the Board. Say he bids

\$8000. This leaves a profit of $8000 - 5800 = \$2200$ $\frac{2200}{2} = \$1100$ will be A's share because he takes the contract, and if 9 other agents are present the other \$1100 is divided between them to cover their expenses for the trip, according as they were graded by the committee A B or C. Say B C D & F were in class "A" and E H & J in Class "B" and G & K in class "C" and if Class A were to get 150, Class B 120 then G & K would each get $1100 - 600 - 360 = 140$ $\frac{140}{2} = \$70$.

But mostly some Bridge Co "has" the county and the Co Surveyor has previously asked the Co to send him a plan to place "on file." The agents would then all make out a cost estimate on the "plan on file" and proceed as before, the Co which "has" the county getting the "concession".

In case of auction bids, the bids stop at a certain figure.

In case of two Bridge Co's being in a "fight" one will not give in and "kick over" the work resulting in every agent handing in a square bid. At auction bids, in a flight, the writer has seen a bridge which would cost \$1150 contracted to be put up ready for traffic for \$300 also one at \$3300 for \$2000.

In this case we will assume the bidding to be "square", & everyone bidding on his own plan.

In many cases, especially in Kas & Okla Terr. the Board comes in for "boodle."

If the Bidding is to be square, the governing factor is low cost; a nice plan and a good talk will also accomplish much.

Most County Boards know that the agents meet & fix a price and often reject all bids and call for new ones.

The designer should never use any sections which are not the lightest of that certain size rolled by the mills. For instance he should not use a 12" I 40#. If a 12" I 31½# is too light, skip the remaining 12" I's and use a 15" I 42#. If a 12" I 40 should be specified ~~and~~ and the designers plan go on file, all agents would be sure to say nothing about it and figure on using a 31½# Beam. Then on securing the contract would substitute the 31½# instead of the 40# and no one except a bridge man with the aid of calipers and a Mill Hand Book could tell the difference, certainly not a Co Surveyor or Commissioner who can hardly tell the difference between an I or [.

Say the 12" I 40# was to be used as a Floor Beam and there are 5 such in the Bridge and each 14 ft long.

$$40 - 31.5 = 8.5\#$$
$$8.5 \times 14 \times 5 = 600\#$$
$$600\# @ 3¢ \text{ erected} = 18^{00}$$
$$\text{also Contract Profit} = 2^{00} = \$20^{00}$$

This may be enough to swing the contract.

Pratt trusses being economical for short spans the Pratt type will be used. We will design a Light Pin Connected Bridge with wood joists and wood hand Rail, a Stiff Bolt or Chord Pin Connected with wood joists and wood hand rail and a Riveted with Steel joists and Steel hand Rail.

The stresses in the three types will be practically the same, the DL varying but little and the L.L. being 1200# per lft Br. for each.

To Get D.L. The wt of the steel in the structure may be secured from several sources, but the estimator can usually make a close guess by practice. Some bridge men can come within 3% if you ask them for instance "What will a 120' Span 14 Roy, weigh.

Say the steel in this case will weigh 200# per lft Bridge.

Assume C to C. chords at 16 ft and divide the truss into 5 panels of 16 ft each this being known by practice to be economical.

Say the joists will be spaced two feet C to C. and this fixes the floor at 2½" thick.

The B. M of the Floor then will be per lin ft Bridge
$2\frac{1}{2}" \times 12" \times 12' \div 12 = 30$
@ 4.5# per ft BM $30 \times 4.5 = 135$#
The Load on the Joists will then be
$100 \times 2 = 200$# for LL and
$135 \div 6 = 22$# for DL = 222# total load per foot
$222 \times 16 = 3560$# total Load on each joist
Trautwine CPC page 234
a 1×14" for 16 ft span safely supports 1020#
∴ a $2\frac{1}{2} \times 14$ supports $1020 \times 2\frac{1}{2} = 2650$# this is for White Pine. For White Oak this is to be increased by 1/3 or 900# ∴ $2650 + 900 = 3550$# which will do therefore the Jsts will be $2\frac{1}{2} \times 14"$ White Oak. These weigh per lin ft Br

$$7 \frac{\times 2\frac{1}{2} \times 14 \times 1}{12} \times 4.5 = 90\#$$

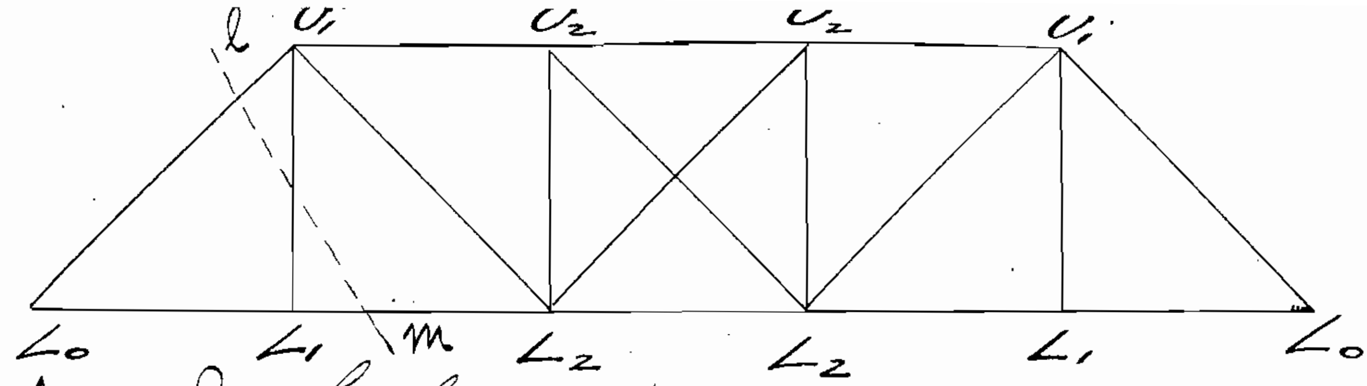
Assume Hand Guard to weigh about 18 to 20# per lin ft Bridge we have then for DL.

Trusses etc	200#
Floor	135#
Jsts	90
Hand Rail	19
	444 per lin ft Br - total-

LL Panel Load = $1200 \times 16 = 19200$
DL " " = $444 \times 16 = 7100$

LL per Panel for Truss = 9600#
DL " " " " = 3550

End Reactions
LL = $9600 \times 2 = 19200$#
DL = $3550 \times 2 = 7100$



DL 7100
LL 19200

In the shop a truss is always lettered as above and the members referred to as L_0U_1, so after a little practice when one hears the member U_1L_1 spoken of, one knows immediately the hanger is meant if a Pratt truss happens to be under discussion, if the member L_2L_2 is spoken of one knows immediately a 5 panel Bridge is under discussion and the middle member of the Lower Chord is meant. If L_3L_3, it would be a 7 Panel Bridge etc.

To Get DL Load Stresses in Chord Members —
Chord Stresses are always found by Moments. A section passed thru L_0L_1 or L_1L_2 and only two additional members gives us a center of moment at U_1 for stresses in L_0L_1 and L_1L_2 and the only force which does not act through this center of moments is the End Reaction. The Stresses in L_0L_1 and L_1L_2 will be the same as they have the same center of Mo — U_1 —
DL Stress in L_1L_2 and also $L_0L_1 = \frac{7100\times16}{16} = 7100$#
Passing a section thru L_2L_2, L_2U_2 and U_1U_2 (one of the Diagonals - the one inclined to the left - being considered idle as it is a counter and we are coming from the left) we find that C of Mo for Stress in L_2L_2 is at U_2 and for U_1U_2 at L_2 therefore these Stresses will be the same.
DL Stress in U_1U_2 and also $L_2L_2 = \frac{7100\times32}{16} - \frac{3550\times16}{16} = 10650$#
DL Stress in $U_2U_2 = \frac{7100\times48}{16} - \frac{3550(32+16)}{16} = 10650$#
To Get LL Chord Stresses - The max LL Chord Stresses occur when the whole Bridge is loaded and are therefore found just like the DL Stresses in the chords. Therefore they will be in direct ratio as the LL Reaction is to the DL Reaction or $\frac{19200}{7100} = 2.71$

L.L. Stress in $\frac{L_0L_1}{L_1L_2}$ $7100 \times 2.71 = 19000$ #

" " " $\begin{matrix} U_1U_2 \\ U_2U_2 \\ L_2L_2 \end{matrix}$ $10650 \times 2.71 = 28900$ #

To Get DL Web Stresses: DL can only occur over the entire Bridge and not over any part of it as does the LL. Therefore the DL Stresses for the web members are found when the entire bridge is loaded. Web Stresses are always found by the aid of the shear - if a diagonal - by the shear in the panel in which the diagonal is situated, if a vertical by the shear in the panel just to the left of the vertical if we are coming in from the ~~right~~ and vice versa. This shear must be multiplied by the secant of the angle which the member makes with the vertical. In this case 45°, secant = 1.41

The shear is always a vertical force, the DL shear in the first panel is the DL Reaction.

A horizontal member cannot take a vertical force therefore the End Post must take all ~~the~~ Reaction and our stress is

$7100 \times 1.41 = 10000$ # DL Stress

+ because the member dips to the left

Our next web member is the hanger. This does not properly belong to the system and takes all the load at its end which is a full panel LL 9600 and 2/3 of a DL Panel as 1/3 is supposed to be in the top chord or $3550 \times 2/3 = 2400$ # DL

DL Shear in Panel $L_1L_2 = 7100 - 3550 = 3550$ #

As U_1L_2 is the only inclined member in this panel

$3550 \times 1.41 = 5000$ # = DL Stress in U_1L_2 = tension

(−) because member dips to the right.

DL Shear in Panel $L_2L_2 = 7100 - 2 \times 3550 = 0$

DL Stress in $U_2L_2 = 0$

To find LL web Stresses. If the bridge were fully loaded we would not get max stresses. As we are working from the left let the loads come on from the right, then the max stress occurs when all panels up to the one we are considering are fully loaded. For the End Post this would mean that the entire bridge should be loaded.

As the load comes on from the right the left reaction receives the following increments

$9600 \times 1/5 = 1920$
$\times 2/5 = 3840$
$\times 3/5 = 5760$
$\times 4/5 = 7680 \quad = 19200^{\#}$ when fully loaded.

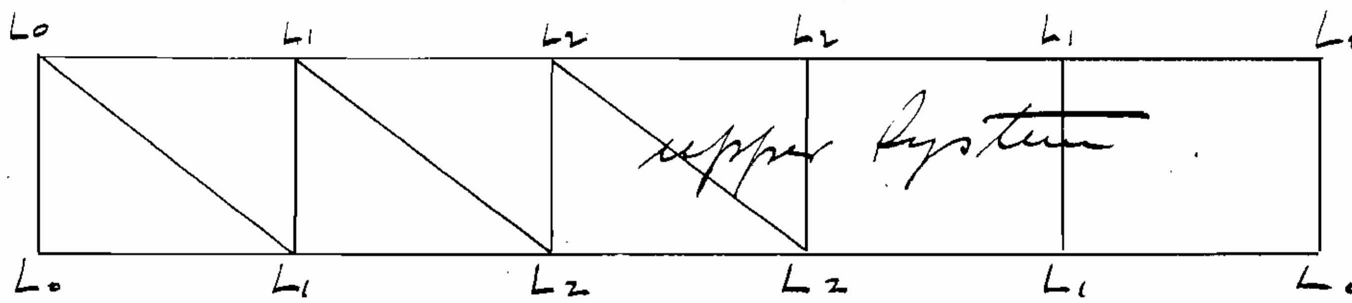
When fully loaded for Stress in End Post
$19200 \times 1.41 = 27100^{\#}$ = Stress in End Post

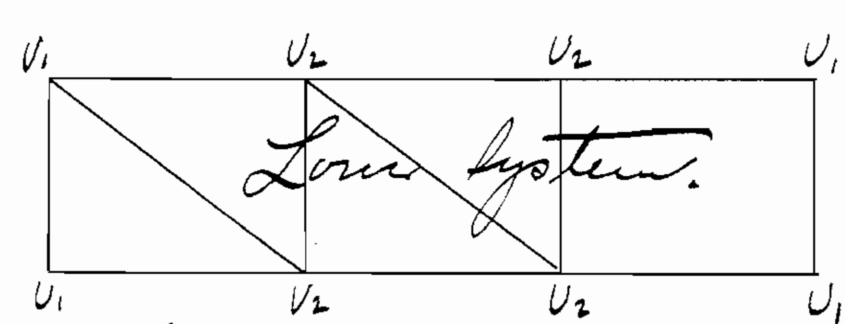
For Diag U_1L_2, $L_2L_2+L_1$ should be fully loaded for Max Shear in Panel L_1L_2 ∴
$(1920+3840+5760) \times 1.41 = 16250$ LL Stress in U_1L_2

For Diag U_2L_2
$(1920+3840) \times 1.41 = 8100^{\#}$ LL Stress in U_2L_2

For Diag U_2L_1 (not shown in sketch)
$1920 \times 1.41 = 2700^{\#}$ But in this panel the DL has passed zero (in the middle panel) and become a + and amounts to $5000^{\#}$ which is more than $-2700^{\#}$ therefore this diagonal is not required.

Stresses in Lateral Systems





tan = 1.25
sec = 1.6
Trusses are 12'-10" c to c.

Only set of diagonals can act at one time. Our Lateral system is then a pratt truss and the stresses are found in exactly the same manner. Stresses in the main truss members L_0L_1, L_1L_2, U_1U_2 etc are neglected because they are not 25% of the LL Stresses in those members. Stresses in L_1L_1, L_2L_2 are neglected because they are taken by the I Beams and do not materially affect the Bending Moment in it.

For the Top Lat System our load is $150^{\#}$ per l ft Br. or $150 \times 16 = 2400$ is one panel load.
Stress in $V_1 V_2$ = shear in panel $\times$ secant or
$$2400 \times 1.6 = 3840^{\#}$$
Stress in Diag $V_2 V_2 = (2400 - 2400) \times 1.41 = 0$

For the Lower Lateral & we have a DL of $150^{\#}$ per l ft Br. also a LL of $150^{\#}$. Both Panel Loads which then is $2400^{\#}$

Stress in $L_0 L_1$
$$DL = 4800 \times 1.6 = 7650$$
$$LL = 4800 \times 1.6 = 7650 \quad = 15300 \text{ Total}$$
Stress in $L_1 L_2$
$$DL = 2400 \times 1.6 = 3840$$
$$LL = 2400\left(\tfrac{3}{5}+\tfrac{2}{5}+\tfrac{1}{5}\right)1.6 = 4610 \quad = 8450^{\#} \text{ Total}$$
Stress in $L_2 L_2$
$$DL = 4800 - 2(2400) \times 1.6 = 0$$
$$LL = 2400\left(\tfrac{2}{5}+\tfrac{1}{5}\right)1.6 = \quad 2300^{\#} \text{ Total.}$$

An Analysis of the Portal Stresses will not be given as it is too lengthy. For this reason all Bridge Cos have their Standard Portals and one for an 80' truss will be seen on tracing herewith.

To design Members.

First & Second Panel Lower Chord members have a stress of $26100^{\#}$. We have been using American Bridge Co Standard Specifications for Highway Bridges thus far, they allow $17000^{\#}$ stress per $\square$" for medium steel in tension, and $15000^{\#}$ for soft steel. All members of a bridge are usually made of medium steel except Rods & Rivets (which are usually made of soft steel as they must be heated, the rivets to be driven and the rods to allow blacksmithing)

$\frac{26100}{15000} = 1.74\square$" required. CPC page 261 gives 2 - $\frac{15}{16}$" Bars as sufficient, but ~~Bars~~ Rods should only be used to the nearest 1/8" therefore we ~~[illegible]~~ use 1"$\square$ but will use $1\frac{1}{8}$"$\square$ for looks

The Middle Panel Lower Chord Member has a stress of $39550^{\#}$
$$\frac{39550}{15000} = 2.64\square\text{" Required.}$$
2 Rods $1\frac{1}{4}$"$\square$ will do.

The hanger has a stress of 12000#

$\frac{12000}{15000} = .8$ 2-5/8"□ would do, but as the designer is properly ashamed of his light bridge he will use 2-7/8"□

It is bad practice to use two Rods for a hanger as it is extremely difficult if not impossible to adjust them so that each receives the same stress.

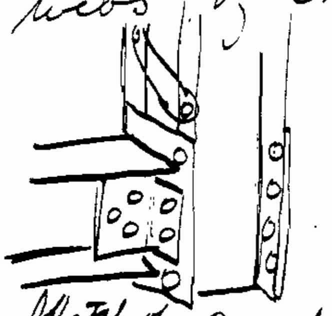
Diagonal in 2nd Panel has a stress of 21250

$\frac{21250}{15000}$ = 1.42□" Req'd. 2 7/8"□ would do but we will use 2-1"□ Rods.

The Counters get 8100# $\frac{8100}{15000}$ = .54□" Req'd 1-3/4"□ would do but we will use 1-1"□

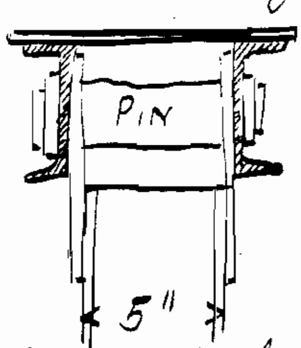
One Rod has been used here because two Rods pass each other in this panel and also because it will fit between the two rods in the next panel. We have been liberal in designing these rods because they are apt to be erected with an initial tension of 5000#

The stress in the Intermediate Post is light and the Post would have to be designed for its $\frac{l}{r}$ which is 120 for a max. in these specifications. Bridge Co's do not usually use a Channel less than 5"-6.5# and as channels are the best sections in this case for floor Beam Connections we will use two 5"[s 6.5# for Int. Post with webs of Channels at ⊥s to axis of Bridge.



Sketch of Floor Bm Connect.

This fixes the distance b to b of [s in top chord at 5" + thickness of connecting plates at top or at least 5½".



Sketch of Top Chord.

The designer knows by practise what size top chord is required unless it be an unusually long span or unusual heavy loading.

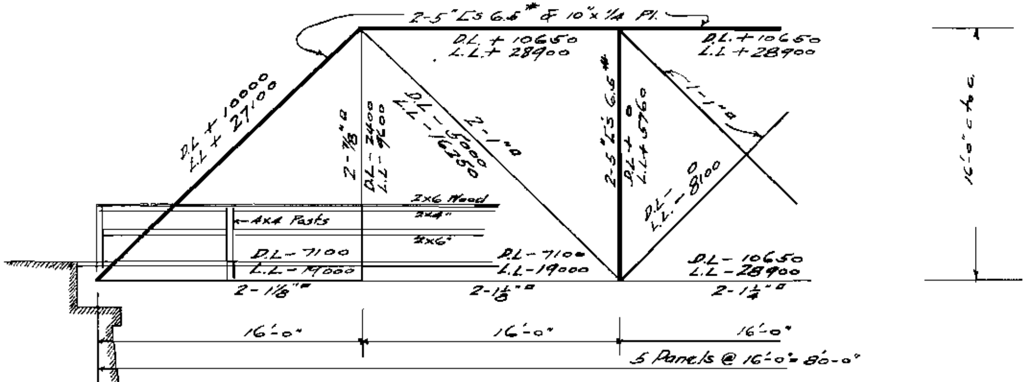
Here 2-5"[s and one 10×1/4 plate will be used. The Channels are 5½" b to b and the flange of a 5"[is 1 3/4" wide (CPC 101) therefore 5½ + 2(1¾) = 9" and a 10" plate is wide enough.

For 2-5" [6.5# & 10×¼ plate $r = 2.00$ & Area = 6.40 □"
Our length is 16×12 = 192 $\frac{l}{r} = \frac{192}{2} = 96$
Using the Formula $p = \frac{17000}{1+\frac{l^2}{11000r^2}}$ $p = 9240$
For Middle Panel Top Chord $\frac{39550}{9240} = 4.28$ □" Required
For End Post our length is $\sqrt{(16)^2+16^2} \times 12 = 22' = 264$
$\frac{264}{2} = 132$ $\frac{l}{r}$ $p = 6580$ $\frac{37100}{6580} = 5.64$ □ Requ'd

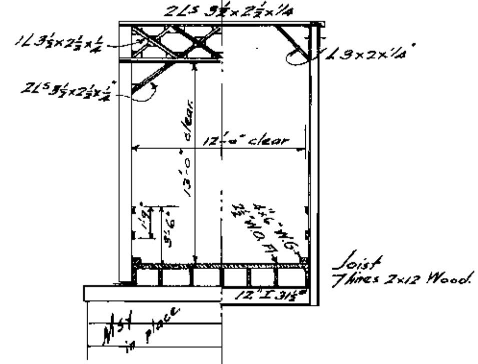
The Bridge Co's have also Standard sets of Lateral for Bridges of different lengths, and the designer need never figure the lateral stresses nor the portal stresses of a bridge unless in unusual cases as before mentioned.

To design Floor Beam. The LL to be carried is one Panel Load or 100×12×16 = 19200#
and the DL is one panel load of flooring and joists, 135+90 = 225×16 = 3600#
Total uniformly distributed Load = 22800#
Take the span as one foot longer than the width of Roy of Bridge = 12+1 = 13 ft.
Moment will be $\frac{22800 \times 13 \times 12}{8} = 467000$ "#

$\frac{467000}{17000} = 27.5$ = Section Modulus Requ'd.
A 10" I 30# (CPC page 98) would do, but for reasons before stated a 12" I 31½# will be used.
We are now prepared to make an estimate of weight & cost of the Bridge.
This is done in the sheet following. The estimator is supposed to be familiar with the details required.
In figuring length of all Rods allow 3 ft extra for the upsets at ends and at turnbuckles.

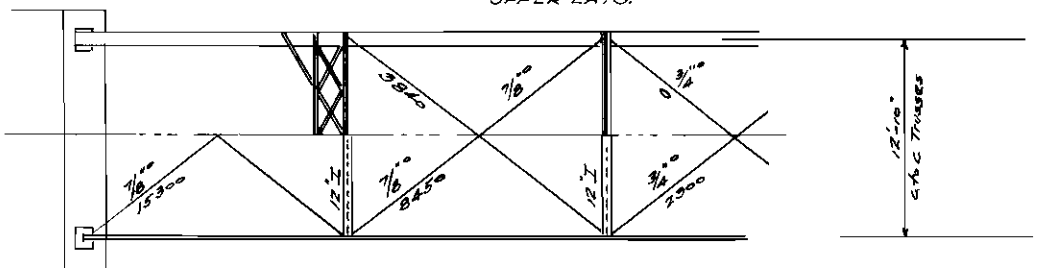


ELEVATION



HALF END VIEW HALF CROSS-SECTION

UPPER LATS.



LOWER LATS.

PROPOSED
80 X 12 PIN CONNECTED SPAN
OVER COW CREEK
BUTLER CO. MO.
H.O. BARN CO. ROAD & BRIDGE COM'R.
Scale 1/8" = 1'-0"

5-04-05

ENGINEERING DEPARTMENT, Kansas City OFFICE. Inquiry No. 6524

ESTIMATE SHEET.

Order No.
Sheet No. 1 of 3
Drawing No.

Estimate made from Our Plan Estimated by FJK 7/4 1902 Checked by — 19

FOR Butler Co Mo 80' PC Truss Span

No. of	Description		Unit Weight	Total Length	L's E's Plts	Rods	Turnbuckles Nuts	
1	80x12 P.C. High Truss							
4	5" E S	48'	6.5	192.0	1250			Top Chords
2	10x1/4	48'	8.5	96.0	815			" "
16	4x5/16	2.0	4.2	32.0	134			Splice Pls
8	10x1/4	2.0	8.5	16.0	136			" "
30	10x1/4	9"	8.5	22.5	191			Battens
8	6x5/16	1.0	6.4	8.0	51			Hitch Pls for Top Lats.
8	5" E S	22.6	6.5	181.0	1175			End Posts
4	10x1/4	22.6	8.5	90.0	765			" "
8	15x3/8	2.0	19.1	16.0	306			Pin Plts at Shoe
28	10x1/4	9"	8.5	21.0	180			Battens
16	1 1/8" □	19.0	4.3	304.0		1310		Lower Chord
4	1 1/4" □	19.0	5.3	76.0		402		" "
8	7/8" □	19.0	2.6	152.0		396		Hip Verticals
16	Turnbuckles for	1 1/8 □	8.5				136	
4	"	1 1/4 □	11.5				46	
8	"	7/8 □	7.0				56	
8	5" E S	17.5	6.5	140.0	910			Int. Posts
24	6x1/4	9"	5.1	18.0	92			Battens
8	8x3/8	15"	10.2	10.0	102			Pin Pls at Top
8	"	2.0	10.2	16.0	163			Pin Pls at Bott & For Fl.Bm Conn.
12	1" □	25.5	3.4	306.0		1040		Diags
12	Turnbuckles for	1" □	7.0				84	
2	3/4" ○	23.0	1.5	46.0		70		Lower Lats
8	7/8" ○	23.0	2.0	184.0		368		" "
2	3/4" ○	23.0	1.5	46.0		70		Upper "
4	7/8" ○	23.0	2.0	92.0		184		" "
4	Turnbuckles	3/4 ○	3.5				14	
12	"	7/8 ○	5.3				64	
4	3 1/2x2 1/2x1/4 L's	14.0	4.9	56.0	274			Top Struts
4	3x2x1/4 L's	3.0	4.1	12.0	50			Knees
8	6x1/4	9"	5.1	6.0	31			Conn. Pls "
8	3 1/2x2 1/2x1/4	14.0	4.9	112.0	550			Portals
16	"	3.5	"	54.0	264			"
8	"	4.0	4.9	32.0	157			"
32	6x1/4	9"	5.1	24.0	122			Conn Pls
					7718	3840	400	

ENGINEERING DEPARTMENT, OFFICE.

Inquiry No. 652 A
Order No.
Sheet No. 2 of 3
Drawing No.

ESTIMATE SHEET.

Estimate made from Our Plan Estimated by FJK 19 Checked by 19

FOR Butler Co. Mo 80 ft [illegible]

No. of	Description		Unit Weight	Total Length	Ls Cs Is P/s	Rods Pins	Turnbuckles Nuts	
4	12 I	12.0	31.5	48.0	1510			Floor Beams
8	Std Connections		23.0		184			For " "
8	8X1/2	2.0	13.6	16.0	218			" " "
20	2"°	1.0	10.7	20.0		214		Pins
4	Cotter Pins		2.5			10		For Laterals
24	Nuts for 7/8°		1.5				36	" "
8	" 3/4°		.68				5	" "
40	Lomas Nuts for Pins		1.0				40	
2	15X1/2	15"	25.5	2.5	64			Fixed Shoes
~~4~~ 2	6x4x1/2 Ls	15"	16.2	~~5.0~~	81			" "
2	4x1/4	1.0	3.4	2.0	6			" " Lat Hitch
4	15X1/2	15"	25.5	5.0	128			Roller Shoes
4	6x4x1/2	15"	16.2	5.0	81			" "
2	4x1/4	1.0	3.4	2.0	7			" " Lat Hitch
10	2"°	15"	10.7	12.5		134		Rollers
4	3x5/16	15"	3.2	5.0	16			Nest
~~4~~ 2	1"°	2.0	2.7	8.0		22		"
8	1"°	1.0	2.7	8.0		22		Anchor Bolts
8	Nuts for Anchors		.6				5	
					2295	402	86	
	From Page 1				7718	3840	400	
					10013	4242	486	
	3% Rivets					442		
					10013	4684	486	

Total Wt 15183#

ERICAN BRIDGE COMPANY.

ENGINEERING DEPARTMENT, ... OFFICE. Inquiry No. 652 A

Order No. ......

ESTIMATE SHEET.

Sheet No. 5 of 3

Drawing No. ......

Estimate made from Our Plan Estimated by FJK 7/4 1902 Checked by —— 19....

FOR Butler Co Mo. 80' Truss Pi.

No. of	Description	Unit Weight.	Total.

To Get Average Price of Material in Trusses

Es Ls Ptc	10013	@ 1.50	=	152.20
Rods + Pins	4242	@ 2.25	=	95.50
Rivets	442	@ 1.80	=	8.00
Turnbuckles + Nuts	486	@ 5.50	=	26.75
	15183			282.45

$\frac{282.45}{151,83}$ = 1.86 F.O.B Pittsburg

Average Price Metal =	1.86
Shop Work	.90
Paint	.05
Freight Pitts to St L	.20
" St L to Butler Co	.27
	3.28

Lumber

Joists	35 - 2×12×16 =	1120
Floor	80 - 2½×12×12 =	2400
W.G	10 - 4×6×16 =	320
Rail	10 - 2×4×16 =	100
"	20 - 2×6×16 =	320
"	14 - 4×4×6 =	110
		4370

Metal 15183 @ 3.28 =	500.00
Lumber 4.5 MBM @ 27.50 =	124.00
Haul 8 Tons 1 mi =	8.00
Erection 8 Tons @ 15.00 =	120.00
Cost	752.00
Profit	150.00
	902.00 Bid Erected.

Some Bridge Cos do not take the time to make an estimate in detail as above, and only take off the main members of the Trusses and in case of a light Pin Connected Truss as this add 25% for details. In this case allow 5 ft extra for each rod to cover upsets at ends and at turnbuckles also for the turnbuckles themselves. Also take the lengths of Floor Beams as two feet longer than the Clear Roadway of the Bridge.

In the Cost estimate these Co's would say the truss costs ---- "at the River"

It will be seen that the weight arrived at by the detailed estimate is 15183 # and by taking off the main members and adding 25% we have 15160 #. These wts are checked up with the shipping weight in case the contract is received and the span is built. A difference of 3% between the estimated and shipping wts is allowable

At present the prices, f.o.b. Pittsburgh of Ls under 6", I's under 25", Flats, Plates, [, Ts, Zs are the same: $1.60 per 100 #. For Ls over 6" and Beams over 24" it is $1.70 per 100 #. At times, plates over 24" wide also cost 10¢ more than the other shapes, this brings up the price of average material.

AMERICAN BRIDGE COMPANY.

ENGINEERING DEPARTMENT, Kansas City OFFICE. *Inquiry No.* 652 A

Order No.

ESTIMATE SHEET.

Sheet No. 1 *of* 1

Drawing No.

Estimate made from Our Plan *Estimated by* FJK 7/4 1902 *Checked by* — 19

FOR Butler Co Mo. 80' Pc. [illegible]

1-80' Pc High Truss

No. of	Description		Unit Weight	Total Length	Wt	See page in CPC for Wt	
4	5" [s	48.0	6.5	192.	1250	7	Top Chords
2	10×1/4 Pls	48.0	8.5	96.	820	255	" "
8	5" [s	22.6	6.5	181.	1180	7	End Posts
4	10×1/4 Pls	22.6	8.5	90.	760	255	" "
16	1 1/8" □	21.0	4.3	336.	1450	261	Lower Chord
4	1 1/4" □	21.0	5.3	84.	450	261	" "
8	7/8" □	21.0	2.6	168.0	440	261	Hip Verticals
8	5" [s	16.0	6.5	128.0	830	7	Inter. Posts
12	1" □	27.5	3.4	330.0	1120	261	Diagonals
2	3/4" ○	25.0	1.5	50.0	80	261	Lower Lats
8	7/8" ○	25.0	2.0	200.0	400	261	" "
2	3/4" ○	25.0	1.5	50.0	70	261	Upper "
4	7/8" ○	25.0	2.0	100.0	200	261	" "
4	3½×2½×¼ Ls	14.0	4.9	56.0	270	41	Top Struts
4	3×2×¼ Ls	4.0	4.1	16.0	70	41	Knees
8	3½×2½×¼ Ls	14.0	4.9	112.0	550	41	Portals
16	"	3.5	4.9	56.0	270	41	"
8	"	4.0	4.9	32.0	160	41	"
4	12 Is	14.0	31.5	56.0	1760	4	Floor Beams
					12130		
	Details 25%				3030		
					15160 # Total Wt.		

Cost at River 15160 × 3.00 = 456.00

Frt KL to site 15160 × .27 = 41.00

Lumber 4.5 MBM @ 27.50 = 124.00

Haul 8 tons 1 mi @ 1.00 = 8.00

Erection 8 Tons @ 15.00 = 120.00

749.00

Profit 153.00

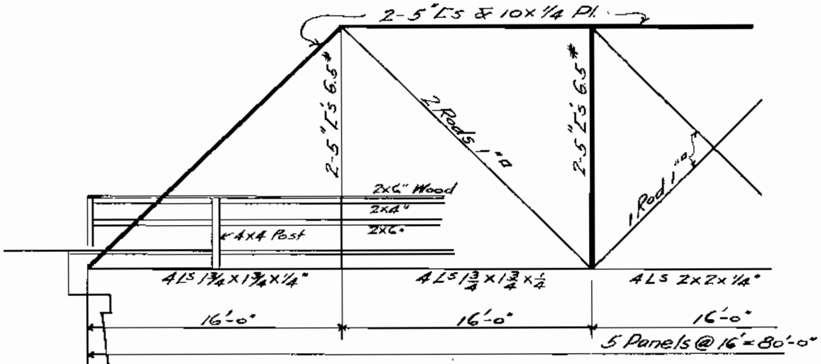
902.00 Bid Erected.

The Stiff Chord Truss is designed like the Pin Conn. except that angles are used in the bottom chord instead of Bars and [s or angles as suspenders in order to stiffen the end panels. The [s in this case are out of proportion to the stresses in the suspender, but the rule is to use 5" [s or Is as the minimum size except in case of the Hand Rail where [s are used for this purpose.

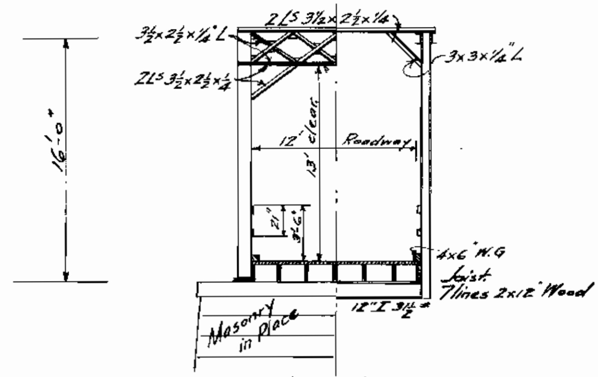
The Laterals are also made somewhat heavier than on the light 80 ft P.C. Truss, not on account of the stress as figured but on account of the initial tension and "looks"

The detailed estimate on the following sheets gives us a weight of 16442# and the percentage of details method gives 16380#. A Truss of this type will usually run 30% detail.

The detailed estimate gives the price of material at Pittsburg as 1.68 and this makes the metal cost "at the River" 1.68+.90+.05+.20 = 2.83, much lower than 3.00. This is caused by the small amount of rods used, thereby diminishing the blacksmith work.

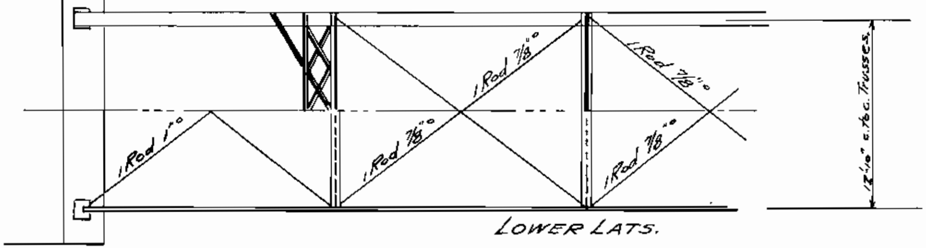


ELEVATION.



HALF END VIEW HALF CROSS-SECTION

UPPER LATS.



LOWER LATS.

PROPOSED
80'x12' PIN CONN. SPAN
WITH STIFF BOTTOM CHORD
OVER COW CREEK
BUTLER CO. MO.
H.O. BARN CO. RD & BR. COMMISSIONER.
Scale 1/8" = 1'-0"

5-4-05

...AN BRIDGE COMPANY.

ENGINEERING DEPARTMENT, ... OFFICE. Inquiry No. 652 +

Order No. ....

ESTIMATE SHEET.

Sheet No. 1 of 3

Drawing No. ....

Estimate made from Our Plan Estimated by FJK 7/4 1902 Checked by — 19

FOR Butler Co 80'-Span Stiff Bott Chord

No. of	Description		Unit Weight	Total Length	Ls Is / Ls Pls	Rods	Turnbuckles Nut	
4	⌐ 5"	48.0	6.5	192.0	1250			Top Chord
2	10×1/4 Pls	48.0	8.5	96.0	820			" "
16	4×5/16	2.0	4.2	32.0	134			Splice Pls
8	10×1/4	2.0	8.5	16.0	136			" "
30	"	9"	8.5	22.5	191			Battens
8	6×5/16	1.0	6.4	8.0	51			Hitch Pls for Top Laterals
8	5" ⌐ "	22.6	6.5	181.0	1175			End Posts
4	10×1/4 Pls	22.6	8.5	90.0	765			" "
8	15×3/8	3.0	19.1	24.0	460			Pin Pls at Shoe
28	10×1/4	9"	8.5	21.0	180			Battens
32	1 3/4×1 3/4×1/4 Ls	15-3"	2.8	488.0	1370			Lower Chord
8	2×2×1/4	"	3.2	122.0	390			" "
60	5 1/4×1/4	5"	4.46	25.0	112			Battens
16	18×5/16	2.0	19.1	32.0	610			Pin Plts
16	⌐ 5 5"	15.0	6.5	240.0	1560			Verticals
48	6×1/4	9"	5.1	36.0	184			Battens
16	6×5/16	15"	6.4	20.0	130			Pin Pls
12	1" □	25.5	3.4	306.0		1040		Diagonals
12	Turnbuckles for 1" □		7				84	
12	7/8" φ	23.0	2.0	276.0		685		Laterals
4	1 φ	23.0	2.67	92.0		245		"
12	Turnbuckles 7/8" φ		5.3				64	
4	" 1" φ		6.0				24	
4	3 1/2×2 1/2×1/4	14.0	4.9	56.0	274			Top Struts
4	3×3×1/4	3.0	4.9	12.0	60			Knees
8	6×1/4	8"	5.1	6.0	31			Conn Pls at Knees
8	3 1/2×2 1/2×1/4	14.0	4.9	112.0	550			Portals
16	"	3.5	"	54.0	264			"
8	"	4.0	"	32.0	157			"
32	6×1/4	9"	5.1	24.0	122			Conn. Pls.
4	12 I	12.0	31.5	48.0	1510			Floor Bms.
16	Std Connections for 12" I @ 23				368			For " "
12	8×1/4	1.0	6.8	12.0	80			Lateral Hitches on F.B's.
20	2" φ	1.0	10.7	20.0		214		
					12734	2184	172	

ENGINEERING DEPARTMENT, ... OFFICE.

Inquiry No. 652 A
Order No.
Sheet No. 2 of 3
Drawing No.

ESTIMATE SHEET.

Estimate made from Or. Plan Estimated by ...... 19 ...... Checked by 19

FOR Butler Co Mo – Stiff Bott Chord

No. of	Description		Unit Weight.	Total Length	Shapes	Rods Pins	Turnbuckles Nuts	
4	Cotter Pins		2.5			10		For Laterals
24	Nuts for 7/8°		1.5				36	" "
8	" " 1°		2.5				20	" "
40	Lomas Nuts		1.0				40	" Pins
2	15X1/2	15"	25.5	2.5	64			Fixed Shoe
4	6X4X1/2	15"	16.2	5.0	81			"
2	4X1/4	1.0	3.4	2.0	6			"
4	15X1/2	15"	25.5	5.0	128			Roller Shoe
4	6X4X1/2	15"	16.2	5.0	81			"
2	4X1/4	1.0	3.4	2.0	6			"
10	2" Φ	15"	10.7	12.5		134		Rollers
4	3X5/16	15"	3.2	5.0	16			" Nest
4	1" Φ	2.0	2.7	8.0		22		" "
8	1" Φ	1.0	2.7	8.0		22		Anchors
8	Nuts for 1"Φ		.6				5	"
					383	188	101	
	From Page 1				12934	2184	172	
					13317	2372	273	
	3% Rivets					480		
					13317	2852	273	

Total lbs 16444

ENGINEERING DEPARTMENT, ... OFFICE. Inquiry No. 1 5 2 A

ESTIMATE SHEET.

Order No. 8
Sheet No. 8 of 15
Drawing No.

Estimate made from Our Plan Estimated by FJK 7/4 1902 Checked by —— 19

FOR Butler Co Mo Stiff Bottom Chords

No. of	Description	Unit Weight.	Total.

To Get Average Price of Material in Trusses

Shapes	13317	@	1.50	=	200.00
Rods & Pins	2372	@	2.25	=	53.50
Rivets	480	@	1.80	=	8.65
Turnbuckles	273	@	5.50	=	15.00
	16442				277.15

$\frac{277.15}{16442}$ = 1.68 FOB Pittsburg

Average Price Metal	1.68
Shop Work	.90
Paint	.05
Freight Pitts to St. L.	.20
" St L to Site	.27
	3.10

Metal 16442 @ 3.10 =	510.00
Lumber 4.5 MBM @ 27.50 =	124.00
Haul 8 tons 1 mile @ 1.00 =	8.00
Erection 8 tons @ 15.00 =	120.00
	762.00
Profit	158.00
	920.00

ENGINEERING DEPARTMENT, ... OFFICE.

Inquiry No. 6042TT
Order No.
Sheet No. 1 of 5
Drawing No.

ESTIMATE SHEET.

Estimate made from Our Plan Estimated by FJK 7/4 1902 Checked by — 19

FOR Butler Co Mo.

No. of	DESCRIPTION		Unit Weight.	Total. Length		
1	80' PC High Truss - Stiff Bot Chord					
4	∠ 5"	48'	6.5	192.0	1250	Top Chord
2	10×1/4 Pls	48	8.5	96.0	820	"
8	∠5	22.6	6.5	181.0	1180	End Posts
4	10×1/4 Pls	22.6	8.5	90.0	760	"
32	1 3/4×1 3/4×1/4 ∠s	16.0	2.8	512.0	1440	Lower Chord
8	2×2×1/4 ∠s	16.0	3.2	128.0	410	"
16	∠s 5"	16.0	6.5	256.0	1660	Verticals
12	1" □	27.5	3.4	330.0	1120	Diagonals
6	7/8°	25.0	2.0	150.0	300	Upper Lats
6	7/8°	"	"	"	300	Lower "
4	1°	"	2.67	100.0	270	" "
4	3 1/2×2 1/2×1/4	14.0	4.9	56.0	270	Top Struts
4	3×3×1/4	4.0	4.9	16.0	80	Knees
8	3 1/2×2 1/2×1/4	14.0	4.9	112.0	550	Portals
16	"	3.5	4.9	56.0	270	"
8	"	4.0	4.9	32.0	160	"
4	12 I	14.0	31.5	56.0	1760	Floor Beams
					12600	
	30% Details				3780	
					16380	

Cost at River 16380 × 3.00 = 492.00
Frt St Louis to Site 16380 × .27 = 44.00
Lumber 4.5 MBM × 27.50 = 124.00
Haul 8 tons, 1 mi @ 1.00 = 8.00
Erection 8 tons @ 15.00 = 120.00

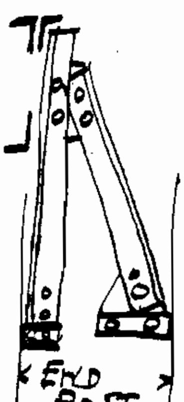
788.00
Profit 162.00

850.00

The Design of the Riveted Truss is similar to the others, except that the estimator is more liberal with his sections. The Laterals are also usually made of angles.

Tension members made of angles should always be attached by both legs in order to develop the full value of the member at the joint, but this is seldom done, hence instead of using 17000# for tension, 12500 is usually used except in long bridges where this method would greatly increase the members. In this case the specifications and drawings call attention to the fact that these members must be attached by both legs and the shop drawings are checked over with this detail in mind among others before they go to shop.

The Hand Rail is usually a standard of the different Bridge Co's whether it is made of wood or steel. It will be noticed that this one runs past the End Post. It is supposed to be braced to it as shown.



It is essential that the hand rail should be as stiff as possible. It has been known that County Commissioners driving out to the site of a completed bridge in order to inspect same for acceptance, climb out of buggy, lay violent hands on the railing and if it shake, condemn the entire bridge. The Co which built the bridge would have a difficult at the next letting.

For Joists we have a load of 80# per sq ft of Bridge, and Jsts being spaced 2' o.c. as they usually are our live load per lft of Jst is $80 \times 2 = 160$. DL is Floor $2 \times 2\frac{1}{2}'' \times 1\text{ ft} \times 4.5 = 22.5$ and assume Joist as $12\frac{1}{4}$#. Total load is then $160 + 12\frac{1}{4} + 22\frac{1}{2} = 200$#

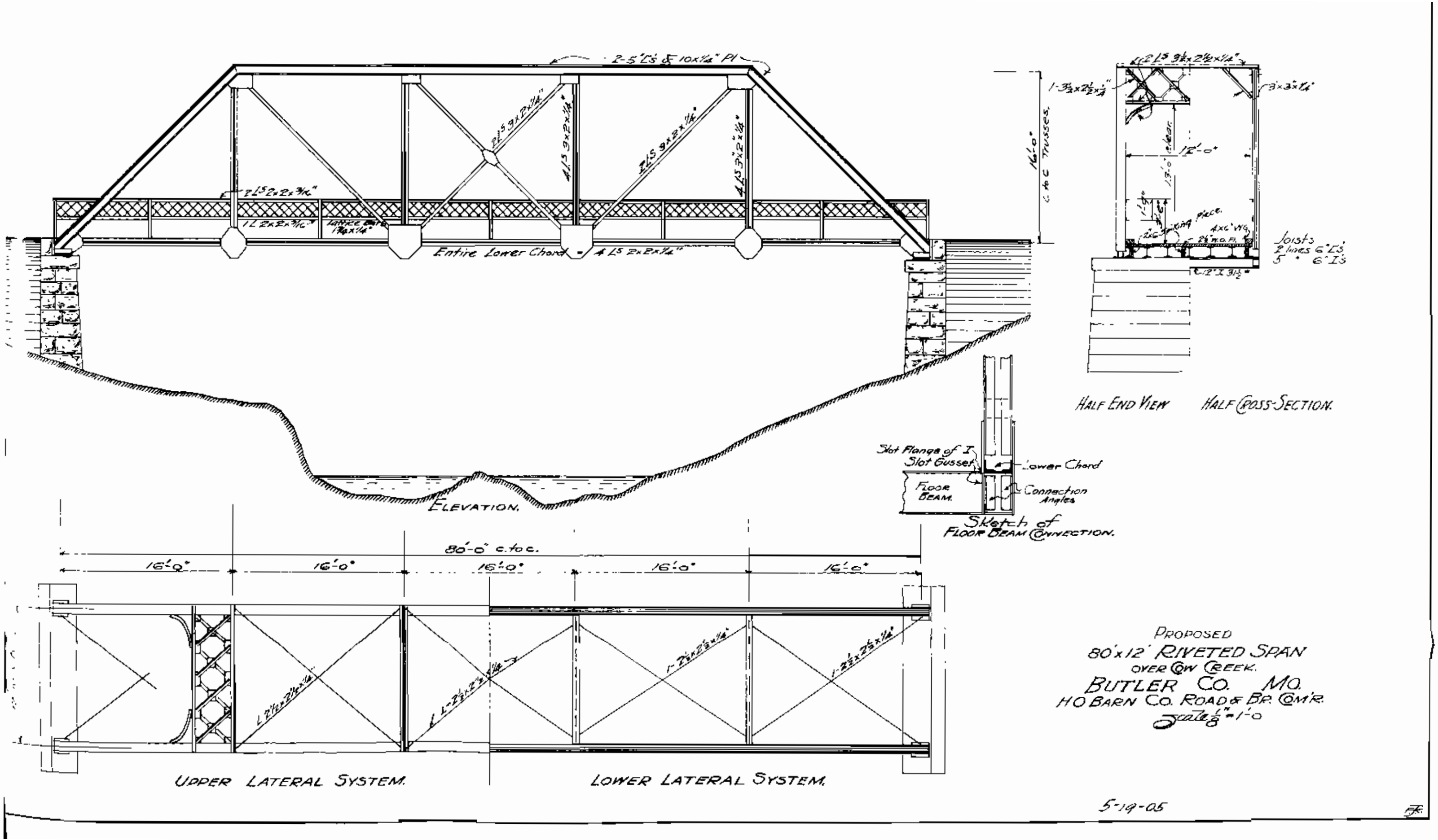
$$\frac{\overset{\text{load}}{(200 \times 16)}\ \overset{\text{length}}{(16 \times 12)}}{8 \times 16000} = 4.84$$ Section Modulus Required

$\frac{200 \times 16 \times 16 \times 12}{8}$ being Mo in inch # & 17000 = allowable fibre stress

Referring to page 100 CPC we see that 5" [s and 5" Is would do, the channels being at the ends get only ½ the load which the Is do. We will use 6" I & [s as 5" are somewhat small for any length of panel & would deflect too much.

< 12' ROADWAY >

[I I I I I]



2 L's 3x2x¼"
4 L's 3x2x¼"
4 L's 3½x2x¼"
2 L's 2x2x3/16"
1 L 2x2x3/16"
Entire Lower Chord - 4 L's 2x2x¼"
ELEVATION.
16'-0" c to c Trusses.
12'-0"
13'-0" clear.
HALF END VIEW
HALF CROSS-SECTION.
Joists
2 lines 6" [s
5 " 6" I's
Slot Flange of I
Slot Gusset
Lower Chord
Floor Beam.
Connection Angles
Sketch of
FLOOR BEAM CONNECTION.
80'-0" c. to c.
16'-0"
16'-0"
16'-0"
16'-0"
16'-0"
UPPER LATERAL SYSTEM.
LOWER LATERAL SYSTEM.
PROPOSED
80'x12' RIVETED SPAN
OVER COW CREEK.
BUTLER CO. MO.
H O BARN CO. ROAD & BR. COM'R.
Scale 1/8"=1'-0
5-19-05

If the items marked with a star on our weight estimate are added we have a total of 13415# for the weight of our main members and
18560 - 13415 = 5145# as the weight of details
$\frac{5145}{13415}$ = 38.3% Details for a Riveted Truss, generally

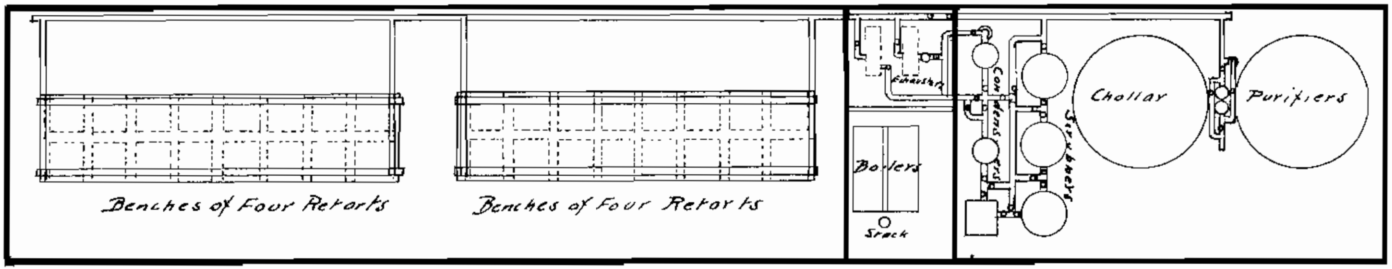
Summing up we have the following Comparison

	Wt. Metal	Average Price of metal	Cost of Erection	Trial Cost
P.C. Light	15183	3.28	120.00	752.00
P.C. Stiff	16442	3.10	120.00	762.00
Riv.	18560	2.89	180.00	849.00

Lumber, Hand Rail, Jts being same for each span.

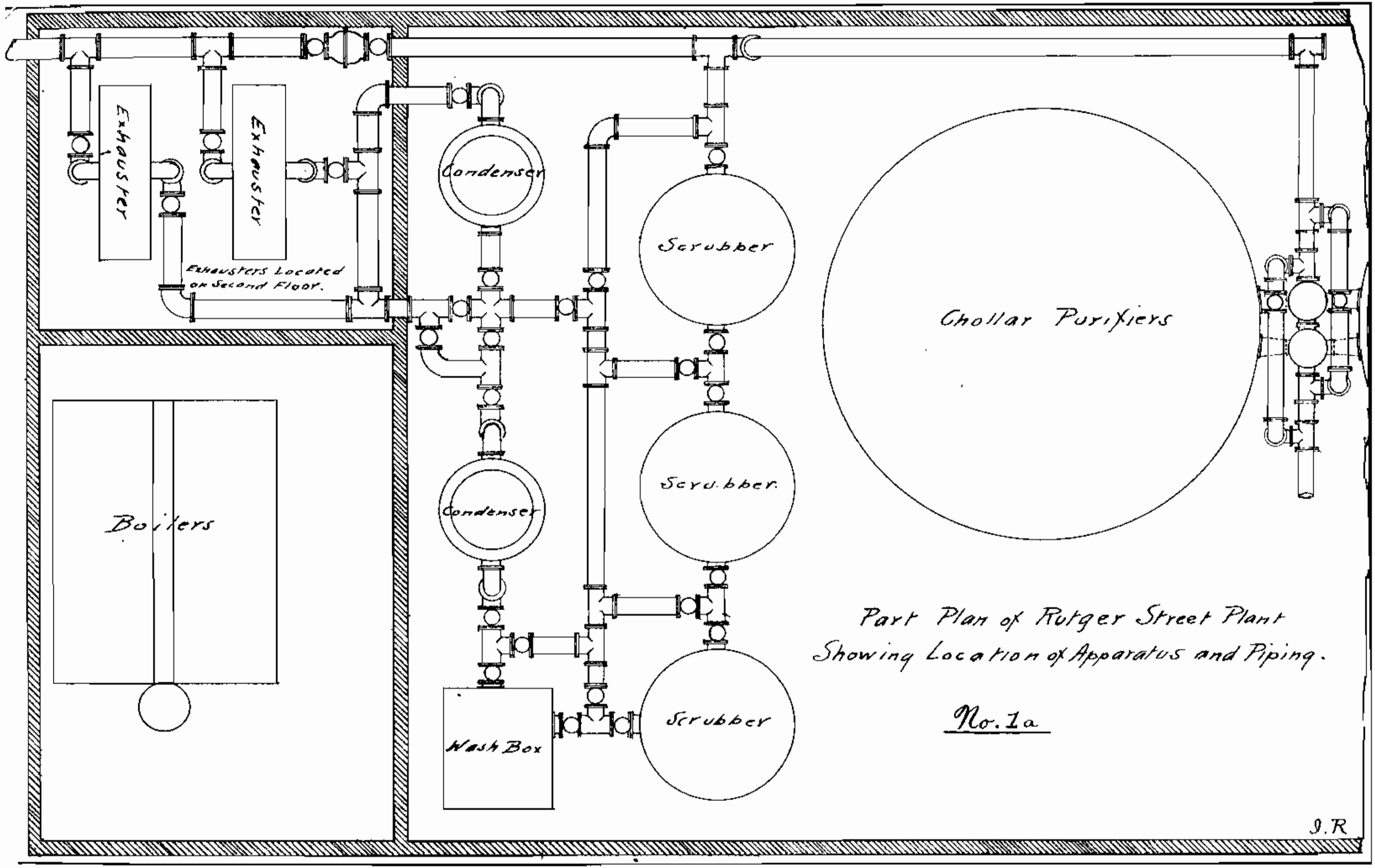
The Cost of erection is higher for the Riveted Span as there is a greater amount of Riveting to be done in the field than on the other two spans.

No. 1



Ground Plan of Rutger Street Plant.

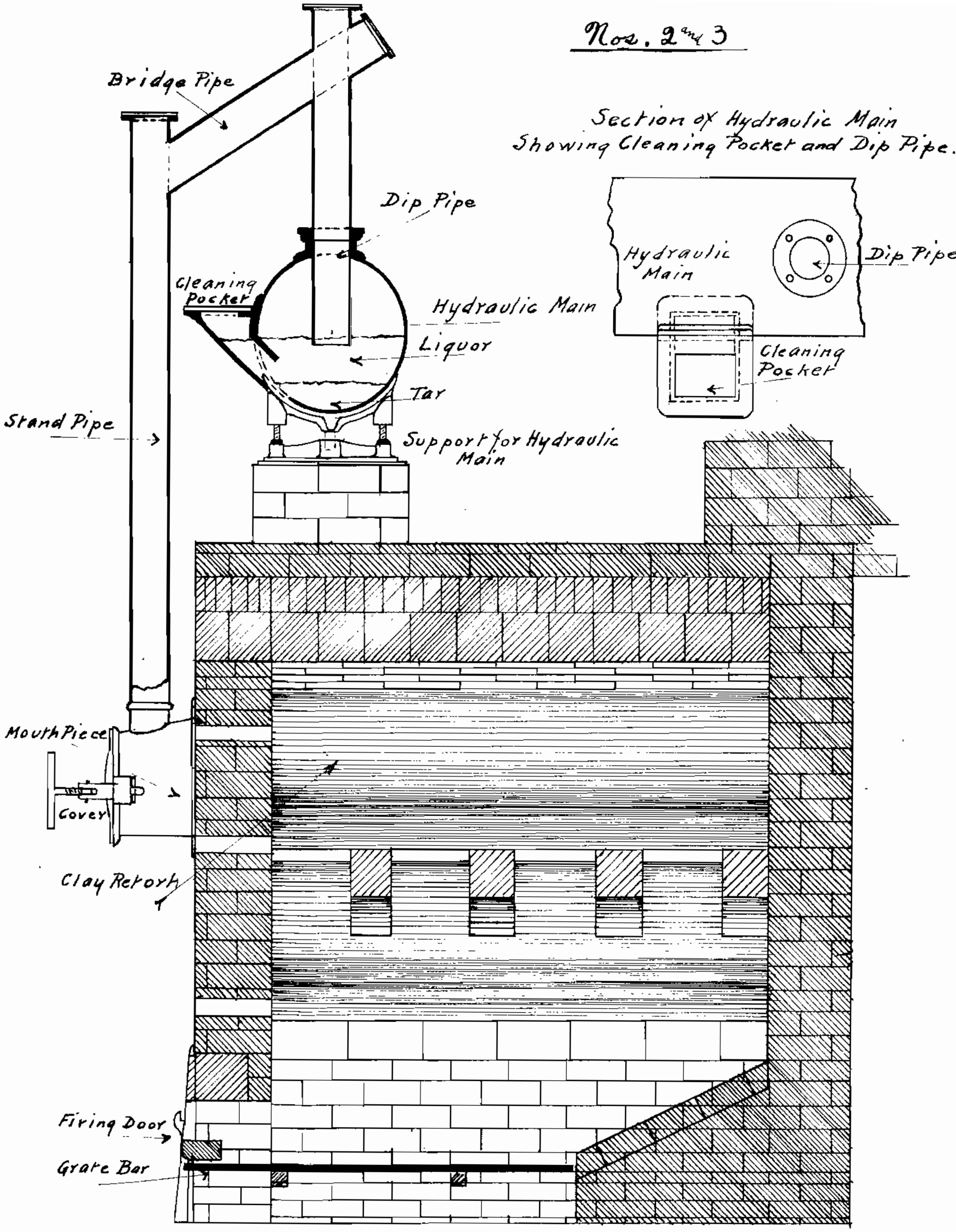
J. R.



Part Plan of Rutger Street Plant
Showing Location of Apparatus and Piping.

No. 1a

Section of Hydraulic Main
Showing Cleaning Pocket and Dip Pipe.

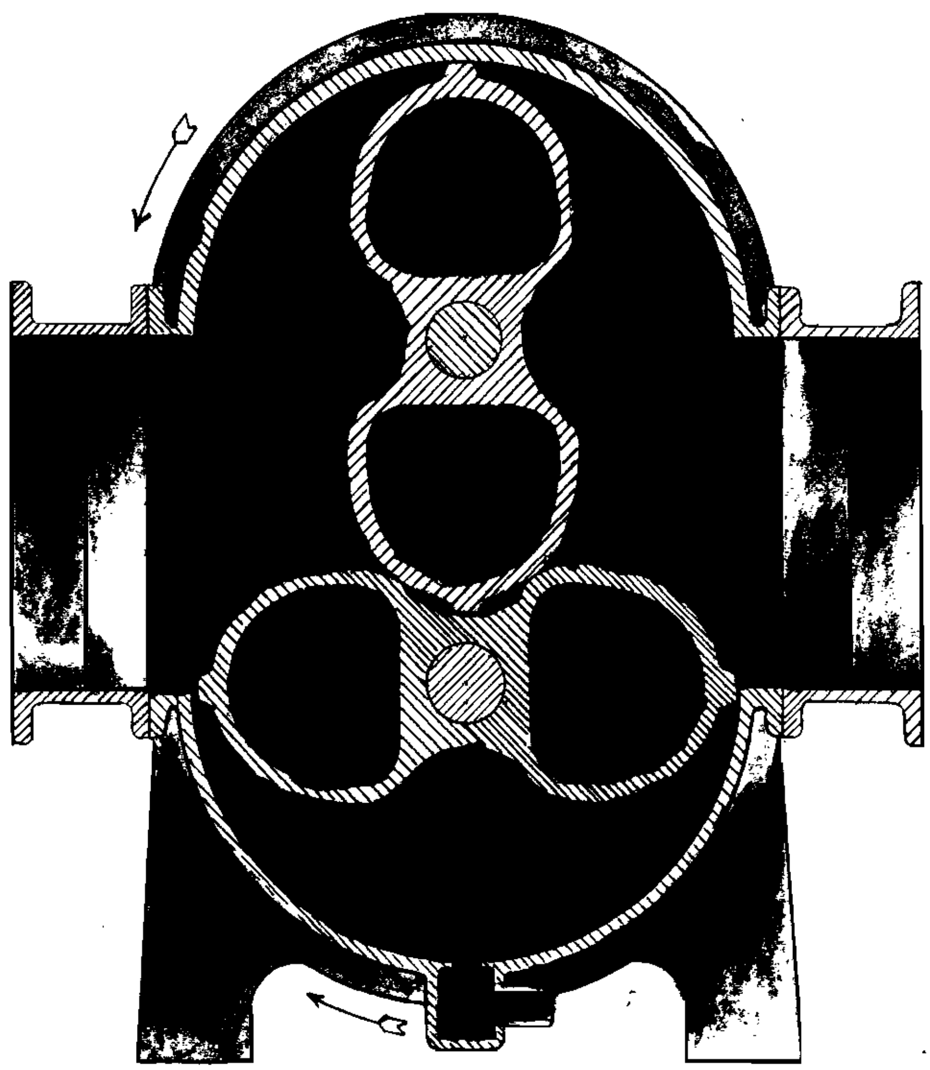


Cross Section Showing Retort Setting,
Hydraulic Main and Accompanying Pipes.

Perspective View of Fire Clay Retort.

J. R.

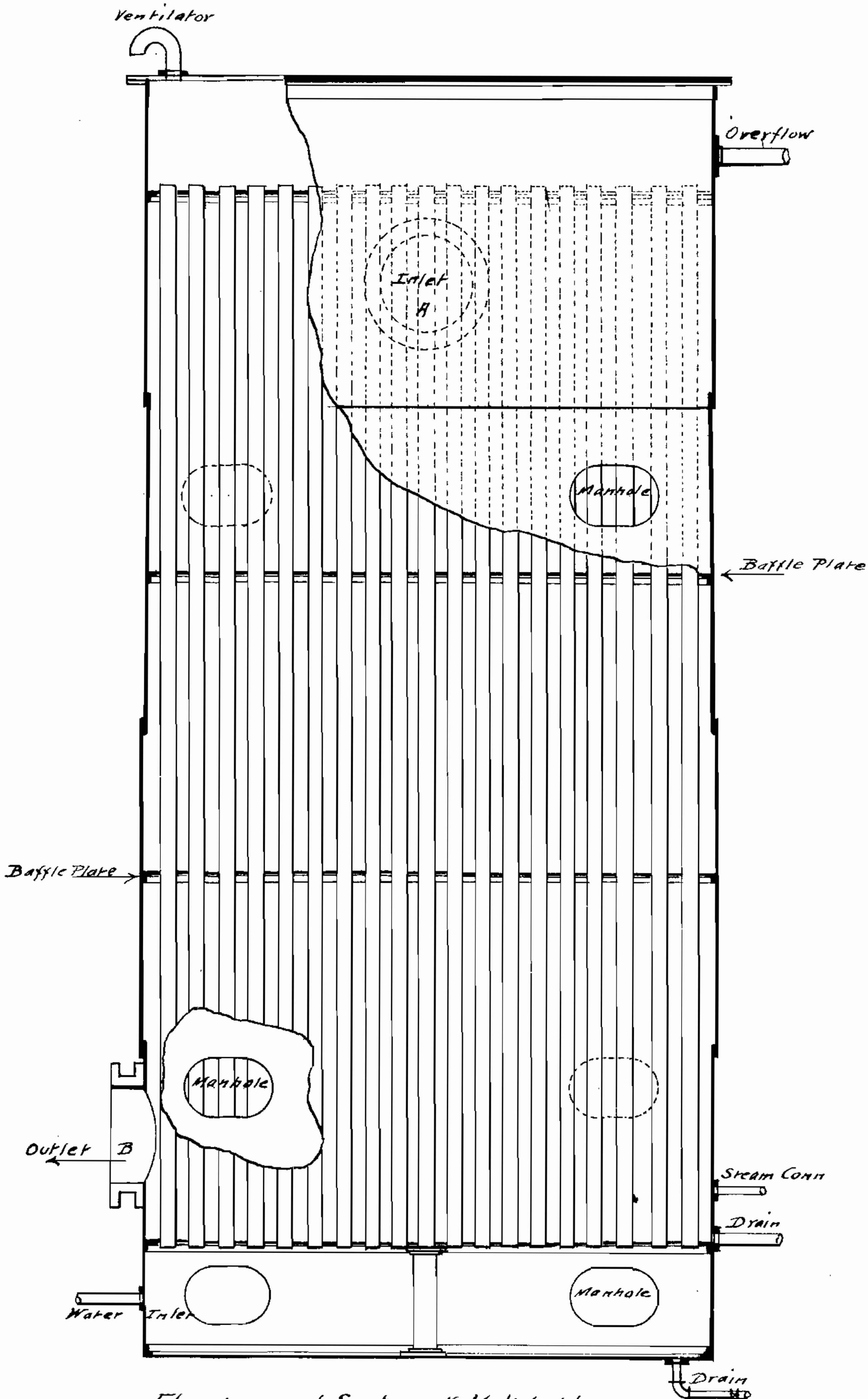
No. 4



Vertical Cross Section of Roots'
Gas Exhauster.

J. R.

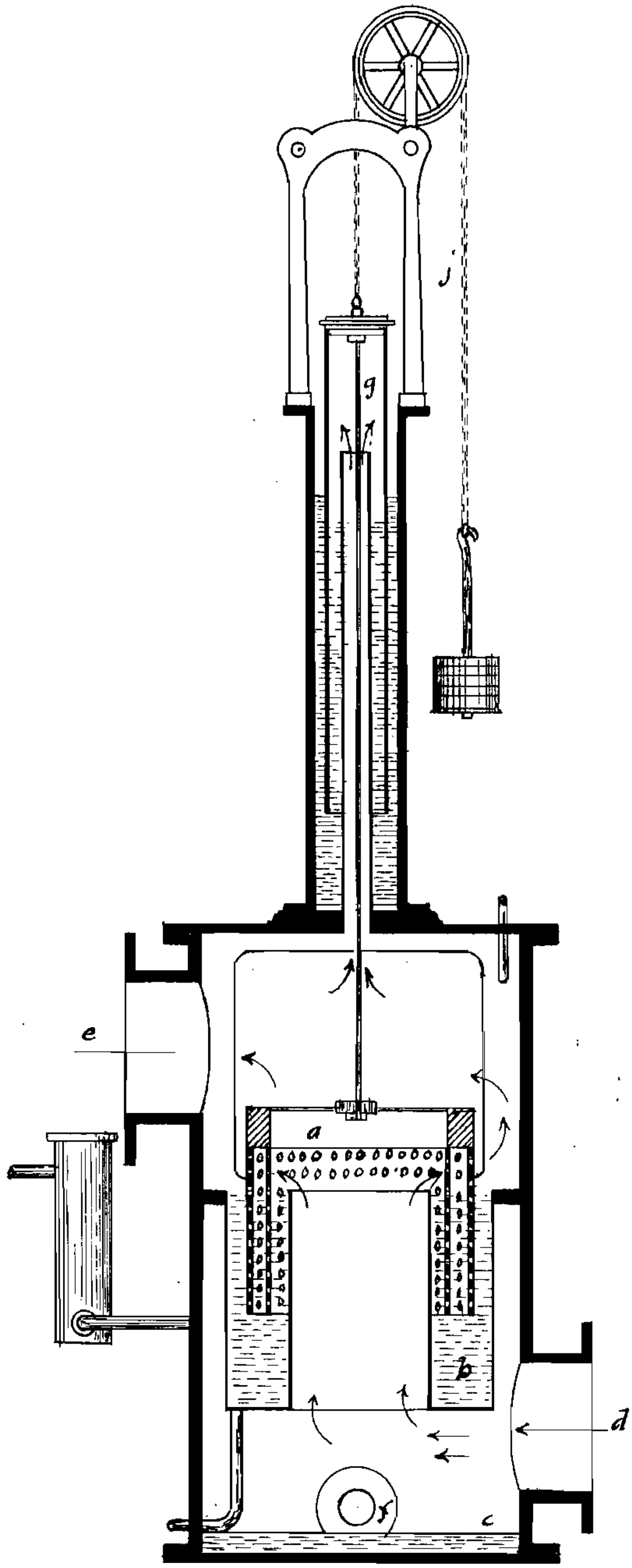
No. 5



Elevation and Section of Multitublar
Gas Condenser.

J. R.

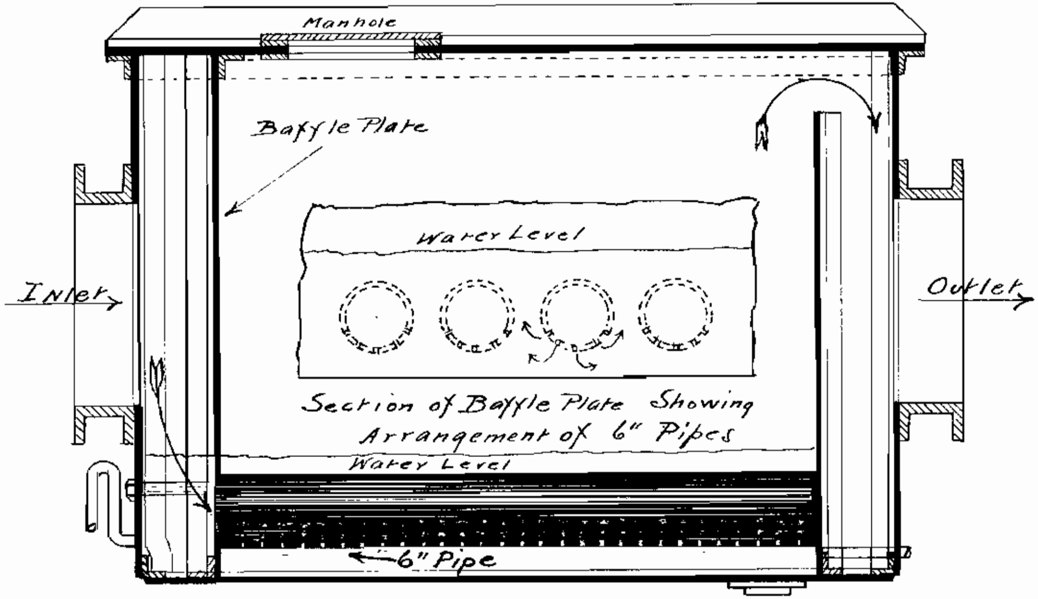
No. 6



Pelouze and Audouins Tar Extractor

J. R.

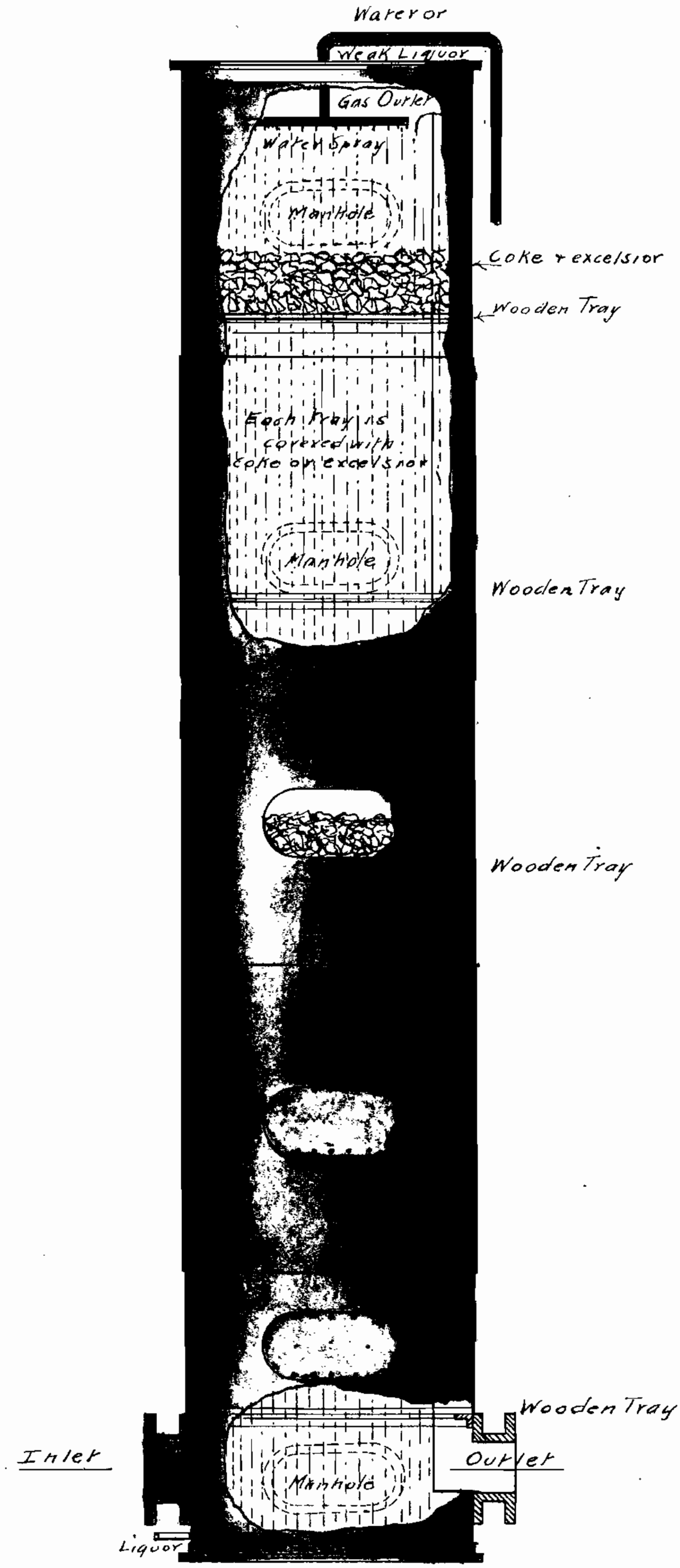
No. 7



Section of Chollar Washer.

J. R.

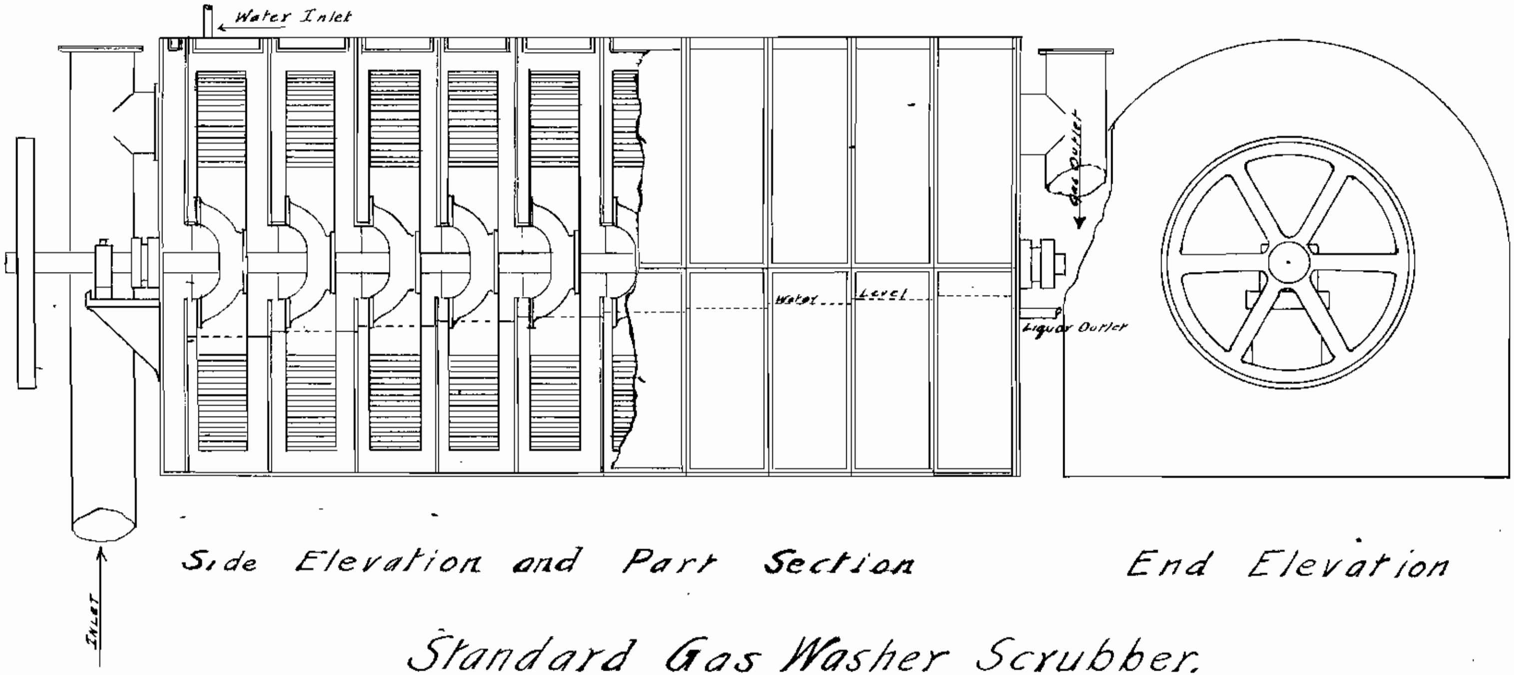
No. 8



Elevation and Section of Tower Gas Scrubber.

J. R.

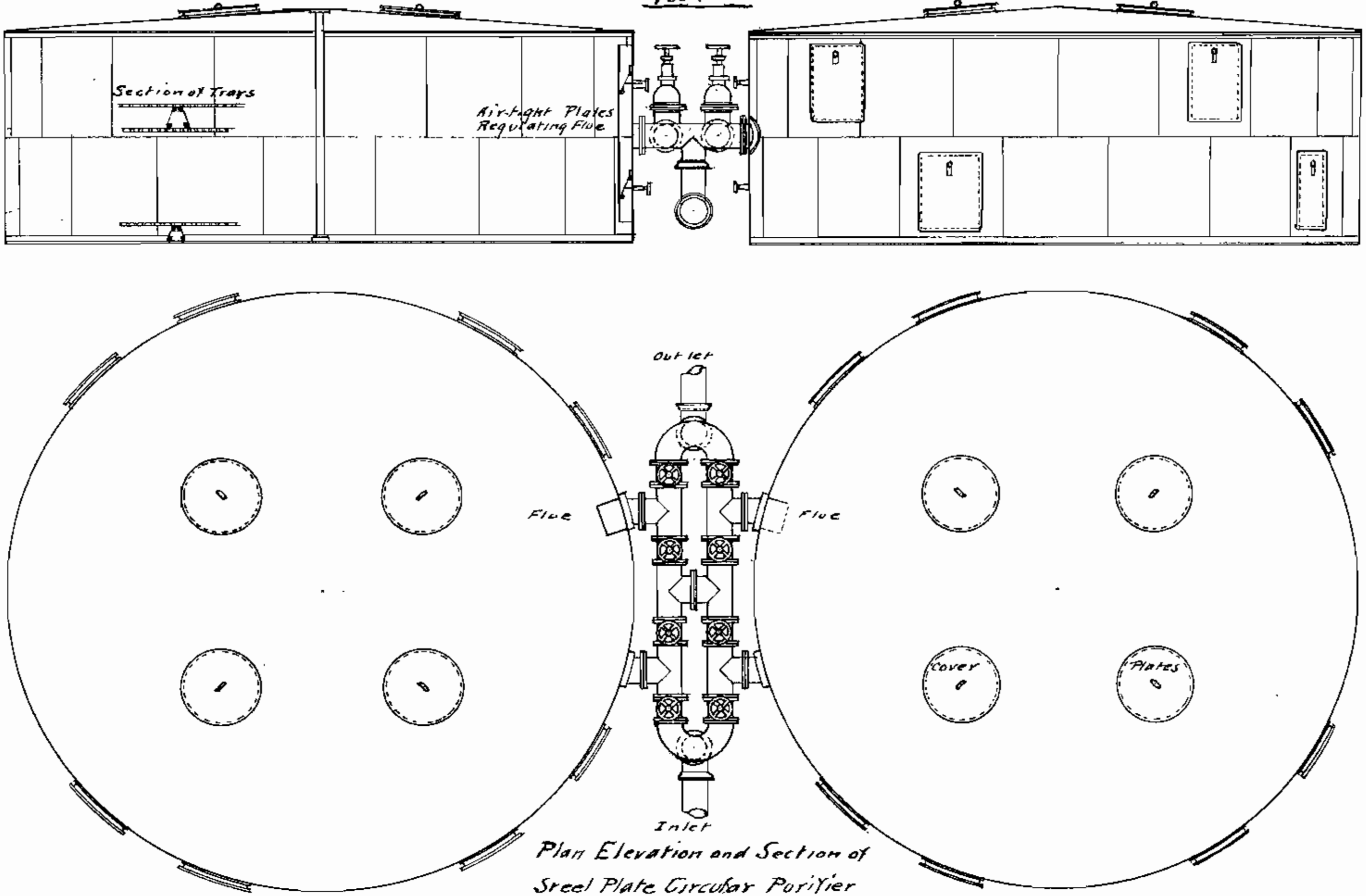
No. 9



Side Elevation and Part Section   End Elevation

Standard Gas Washer Scrubber.

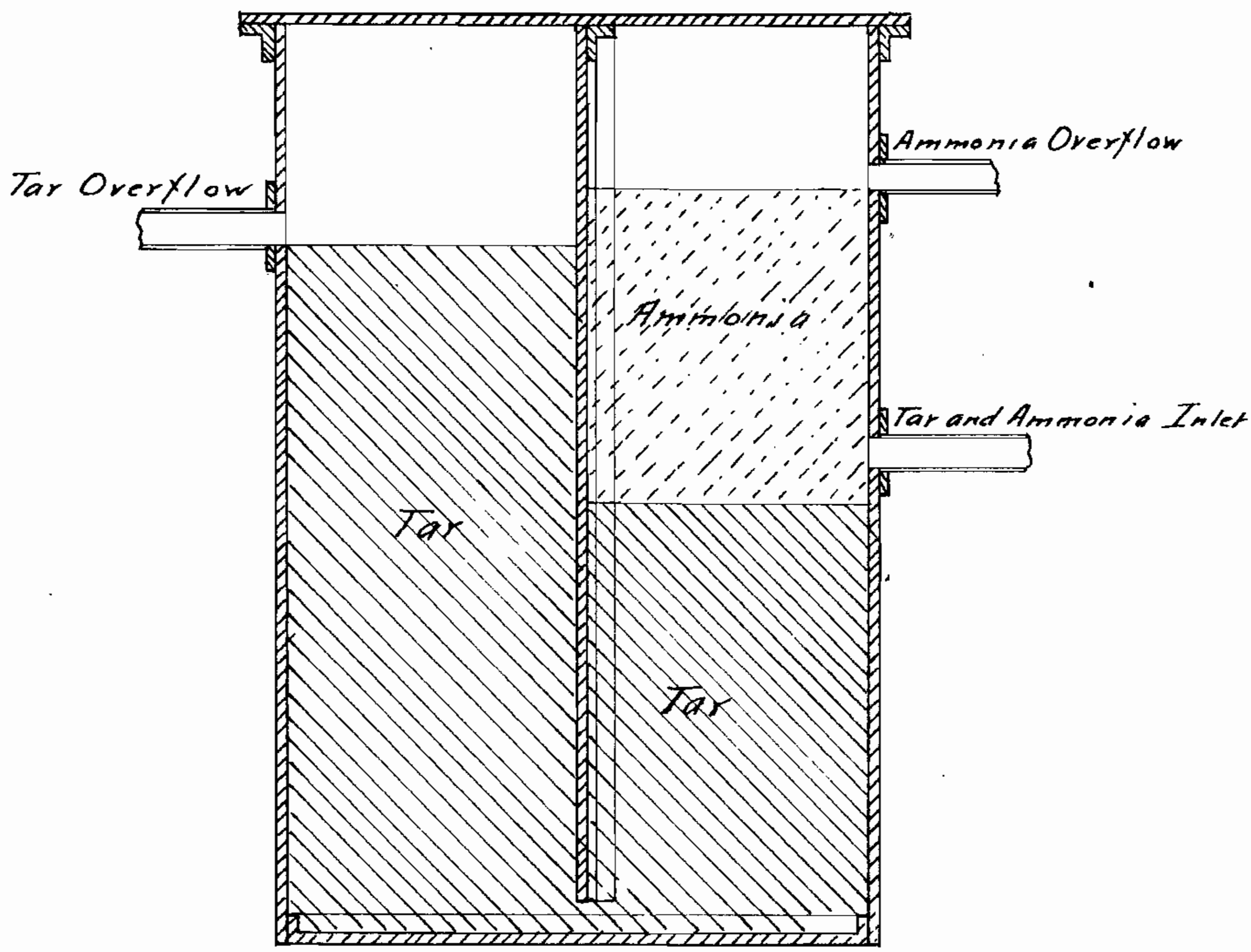
No. 10



Plan Elevation and Section of Steel Plate Circular Purifier

J. R.

No. 11



Cross Section of Coal Gas Tar Separator.

J. R.